THE ENGINEER

A Seven-Day Journal

The Society of Chemical Industry

THE seventieth annual meeting of the Society of Chemical Industry is being held in London this week. The proceedings began on Monday evening last, the first event being a reception at the Geological and Science Museums, South Kensington, arranged by the London section of the Society. On Tuesday and the succeeding days, there has been a series of visits to works and other places of scientific and general interest, including the laboratories and research centres of over forty establishments in and around London. The presidential address was delivered by Mr. Stanley Robson on Tuesday morning, and on Tuesday evening there was a reception by the University of London at Senate House. The Society's Medal was presented, on Wednesday morning, to Professor E. C. Dodds, who delivered an address on "The Decisive Influence of the Chemical Industry on Medicine." The general theme of the papers presented for discussion at the technical sessions is "Water in Industry," the subject being introduced by Mr. H. W. Cremer. Altogether fourteen lectures and papers have been given during the week, dealing with the availability of water supplies, the disposal of waste waters, water and crop production, the science of hydroponics, and corrosion problems. The meeting concludes this evening with a reception at the Connaught Rooms by the chairman and directors of Imperial Chemical Industries, Ltd. Mr. John Rogers, chairman of I.C.I., Ltd., is the President-elect of the Society.

Kariba Gorge Hydro-Electric Project

PROPOSALS for harnessing the Zambesi River at the Kariba Gorge at a total estimated cost of £74,500,000 are given in the report of the Inter-Territorial Hydro-Electric Power Commission, which has just been published by the Central African Council. The Commission was set up by the Council in 1946 to study the possibilities of the Kariba and Kafue hydro-electric power projects and any other large sources of power available for joint development in the area, and its report is now being considered by the Governments of Northern and Southern Rhodesia. It proposes that the scheme should be carried out in two stages, an initial stage of 385MW, which would cost £43,500,000, and a final stage of 1000MW, which would bring the total cost to £74,500,000. The construction of the first stage would take eight years to complete. The Commission is satisfied that the load development estimates in the territories to be served are sound, and that the Kariba scheme affords the most economic source of bulk power available. The immediate potential load in Northern Rhodesia from the copper companies alone is about 100MW. In Southern Rhodesia the demand of the Salisbury Midlands area is expected to be between 270MW and 380MW in 1962, depending on the rate of growth, while the Shabani, Gwanda and Bulawayo areas, in the aggregate, afford similar potential loads. The Commission's report states that if the project were carried out it would enable hydro-electric power to be delivered at receiving stations at a cost of 0·253 pence per unit for the initial development and at 0·170 pence per unit for the final development, comparing with an estimated cost of thermal power delivered to the Salisbury Midlands area of 0·477 pence per unit at the end of 1961 and 0·41 pence per unit in 1971. The Commission has recommended that control of the undertaking should be in the hands of a "Rhodesia Hydro-Electric Power Authority" established by the Governments with appropriate territorial representation. The Authority would own the works at Kariba, together with the transmission lines and associated apparatus, and would sell bulk power. The Commission also recommends that to collect, study and disseminate information on the Zambesi River, and to act as a Water Court, an international authority consisting of representatives of all the riparian territories should be set up to consider all matters affecting common interest in, and common usage of, the river by riparian territories. Regarding communications, it is pointed out that if it is decided to proceed with the scheme and to complete it by 1961, a rail or road connection to the dam site will have to be provided by 1954–55. Although road transport would be possible in the initial stages of construction, it would be relatively costly, involving heavy capital expenditure on improvements to the existing Sinoia-Chirundu road. It is pointed out, however, that the site of the dam is in the area of the proposed Sinoia-Kafue rail link.

Report of the Valve Industries' Productivity Team

THE Anglo-American Council on Productivity has now published the report of the productivity team which recently toured the United States to study valve manufacture. The team was one of the first to devote much of its visit to the study of engineering machine shops in the U.S.A. Many of the remarks in the report follow along similar lines to the points made by previous teams, exemplifying the differences in attitude towards industrial production in this country and in the U.S.A., but these remarks will, doubtless, be of great value in the valve industry in this country. The more important of the team's recommendations are enumerated herewith. They include a more extensive mechanisation of the handling of valves and components; improvement in the utilisation of machines and the introduction of special or multi-operation machines wherever quantities justify them; an attempt at more widespread use of power devices, such as air or electric wrenches, air vices, air-operated jigs and testing fixtures; a study of the advantages of standardisation, specialisation and simplification; the fostering of technical education of staff to the greatest possible extent; the maintenance of close personal contact between management and men; and a study of the use of welding techniques for fabrication. In addition, several recommendations were addressed specifically to "the man in the works," including the advice to look upon any work-saving device as an asset, and not a threat to regular employment, and the opinion that if a man is fit to do a job, whether he was apprenticed or not, he should be allowed to take his opportunity.

Naval Architects' and Marine Engineers' International Conference, 1951

THE London proceedings of the International Conference of Naval Architects and Marine Engineers were concluded with the official dinner on Friday, June 29th, and the delegates went by rail to Glasgow on Sunday, July 1st. No papers were read at Glasgow and the members spent Monday visiting various shipyards and engine works on the Clyde and completed the day by inspecting the Engineering Centre in Sauchiehall Street. Some, however, made the journey by air to Belfast to see the yards of Harland and Wolff, Ltd. On the following day delegates and guests made a cruise down the Clyde in the veteran Tr.S.S. "King Edward." It was particularly suitable that the "King Edward" in her jubilee year should carry the naval architects and marine engineers attending the conference on their cruise. On Tuesday evening the members of the conference were received by the Senior Magistrate, Balie Mrs. Dewar, and the Corporation of the City, in the City Chambers. There was a coach tour of Glasgow on Wednesday morning and there the delegates were entertained to luncheon by the host institution, the Institution of Engineers and Shipbuilders in Scotland, before joining their train for Newcastle upon Tyne. At Newcastle the proceedings were opened under the chairmanship of Sir Philip B. Johnson, the President of the North-East Coast Institution of Engineers and Shipbuilders, by the reading of two papers, followed by an informal luncheon, after which some of the delegates visited works on Tyneside and the Wearside. A banquet was given by the North-East Coast Institution of Engineers and Shipbuilders on Thursday evening, when the delegates were received by Sir Philip B. Johnson and Lady Johnson. The Lord Mayor of Newcastle upon Tyne, Alderman McKeag, proposed the toast of "Our friends from overseas," and after referring to local men, famous in the world of engineering, mentioned that the oceans were still unconquered and continued to offer a challenge to the skill of naval architects and marine engineers. Mr. J. H. King, President of the Society of Naval Architects and Marine Engineers, replied to the toast and stressed the seriousness of the present-day situation and said how necessary it was that the nations should maintain a firm friendship and allow nothing to come between them. Ingenior H. Sjöholm, President of the Naval Architecture and Aeronautics Section Svenska Teknologföreningen, also replied on behalf of the guests. On the last day of the conference various shipyards and engineering works were visited and the delegates were entertained to luncheon by the firms concerned.

The Tin Research Institute

IN our issue of June 8th we described the new laboratories of the Tin Research Institute at Greenford, Middlesex. This week there has been published the annual report of the Institute, which records the work accomplished during 1950. The Institute is controlled by the International Tin Research and Development Council, its researches being directed to developing the use of tin and its alloys and to the development of industrial processes in which tin may be employed. The report says that work was continued throughout last year on the study of the electro-deposition of tin-alloy coatings, one notable achievement being the invention of a new tarnish-resistant electroplate consisting of 65 per cent tin and 35 per cent nickel. The tin-nickel is deposited in bright condition, requiring, it is claimed, little or no polishing. Pilot plants for the application of the process are to be installed in this country, Holland and the U.S.A. The laboratory was engaged last year in servicing the large number of users who have installed the tin-zinc plating process. The report comments that the adoption of this relatively new use of tin has been stimulated by the shortage of cadmium, and tin-zinc plating is already regarded as a satisfactory and relatively cheap substitute for cadmium plating. The report also deals with the work carried out on corrosion tests, chemical analysis, properties of bearings, bronze and the manufacture of electrolytic tinplate. New fundamental researches, which were initiated, included a study of the theory of alloy formation and the preparation and properties of new organo-tin compounds.

The South Bank Exhibition

No. XI—(*Continued from page 4, July 6th*)

TO engineers one of the more interesting sections of the Dome of Discovery is that concerned with the physical world: it portrays some of the historic discoveries that foreshadowed many of the technical achievements of the present era. It shows some aspects of the important contributions made by British engineering skill in applying the discoveries of British scientists. It indicates, for example, the link between Faraday's work and electric power; Maxwell's researches and the theory and practice of radio propagation, and Ambrose Fleming's work on the diode valve and modern achievements in radio communication and electronic engineering.

A typical example of electronics applied to an industrial process is the radio-frequency induction heater demonstrated by Radio Heaters, Ltd., as a self-contained mains-operated automatic equipment for hardening pawls on a production basis. The equipment, as illustrated herewith, is a standard "Radyne" 1kW radio-frequency generator embodying a small rotating table on the circumference of which the pawls are loaded by hand. Rotation of the table is intermittent, the movement being indexed to bring each pawl in turn between the

RADIO FREQUENCY INDUCTION HEATER

turns of a high-frequency heating coil which is itself water cooled. After leaving the heating coil the pawl is brought, by the next movement of the table, under a water jet for quenching. The arrangement of the table, heating coil and water jet is clearly shown in one of our illustrations.

In normal operation the speed of the table and the coil output would be set so that one pawl would be hardened every two seconds, and the hardened pawls would be ploughed off down a chute. For convenience, however, the equipment demonstrated in the Dome of Discovery is slowed down, the length of the hardening cycle being increased to thirty seconds; furthermore, the hardened pawls are not ploughed off the table.

The automatic control of industrial processes is well exemplified in an exhibit consisting of a hydrogen chloride absorber with its control panel. The HCl absorber

ROTATING TABLE OF R.F. INDUCTION HEATER

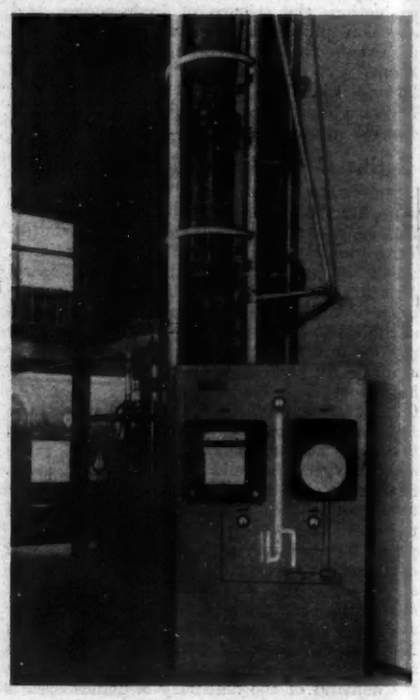
consists essentially of a 25ft tubular column built up of a number of glassware elements with bolted flanges, as indicated in the accompanying illustration. In the operation of the absorber, concentration of HCl is accompanied by the generation of heat. Automatic control of the absorption process is achieved by reference to the flow of the incoming gas and the temperature of the hot zone of the absorber; the system operates by controlling the flow of "make" water to maintain concentration of the acid within the limits required for commercial purposes.

The automatic control panel is a steel cubicle, as illustrated, containing an "Elliottronic" potentiometer recorder controller with a circular chart recording and transmitting flowmeter. A Fisher diaphragm motor valve in the supply line controls the flow of water under the influence of a ratio controller associated with the flow recorder. The ratio setting can be modified by reset action provided by the "Trimode" controller in the potentiometer recorder. Because of possible fluctuations in the HCl input to the absorber it is necessary to introduce integral and derivative functions into the control system; the "Trimode" controller allows these functions, together with the proportional band width, to be set up on calibrated dials.

Although the absorber and the control are installed side by side in the exhibit, the absorber may, in practice, be erected in an exposed part of the plant. The panel is therefore designed to be installed for remote operation. Accordingly, to give the operator sufficient information to allow him to exercise supervisory control of the process, the panel incorporates an illuminated model of the absorber, with a flow diagram of the process, and remote reading electrical thermometers to indicate the temperatures at various parts of the column.

The glassware for the absorber column was supplied by Quickfit and Quartz, Ltd., and the automatic control panel associated with the absorber is a product of Elliott Brothers (London), Ltd.

An instrument of a very different kind is the Elliott differential analyser, which is an electro-mechanical equipment for solving differential equations and other mechanical problems. It consists of five integrators, six adders, one output table and one rotary input table, an independent-variable generator and various supply and control circuits. The integrators are ball-and-disc mechanisms, in which a ball is rotated by being in contact with the plane face of a disc, 5½in diameter, rotated about its axis; the ball can be traversed along a fixed diameter of the disc and the amount of rotation imparted to the ball is proportional to the angular rotation of the dics and to the radial displacement of the ball from the centre of the disc. In this way the ball and disc mechanism performs the operation of integration. The design of the adder units is based on the properties of the Magslip system of electrical transmission. To provide a range of "constants" there are a large number of standard four-ratio gearboxes throughout the system. The analyser differs from its predecessors mainly in its use of electrical



AUTOMATIC CONTROL PANEL AND HCL ABSORBER

transmission, all shaft rotations being converted into electrical signals by Magslip transmitters.

The instrument is designed and constructed as an assembly of units so that its capacity can be increased by the addition of further units. The inputs and outputs of all the component units are brought to three control cabinets where they are terminated in telephone-type sockets. A problem is set up by plugging connecting links into the appropriate sockets. The control cabinets

also house the various power supply units and servo-amplifiers.

Apart from feeding the "driving functions" into the differential analyser, the input tables referred to above are used for dealing with non-linear characteristics These characteristics are drawn on the input tables and are fed by a follower mechanism into the analyser during the process of solution. It is convenient to supply standard functions to the machine through the input tables, because the generation of such functions would involve the use of integrator and adder components which are required for other purposes. The rotary table to which we have referred is particularly useful for supplying periodic functions to the differential analyser.

Two other examples may be quoted from the sequence of exhibits in the Dome, illustrating some of the industrial applications of electronic techniques. The first is a photo-electrically operated mechanism designed and made by Sargrove Electronics, Ltd., for the automatic sorting of objects according to colour differences. The second exhibit is arranged as a working demonstration of the Cossor double-beam cathode-ray oscillograph. Here the oscillograph is connected for monitoring the valve motion of an oil engine, the shape of the trace giving a visual interpretation of the motion.

TELECINEMA PROJECTION ROOM

THE TELECINEMA

The Telecinema at the South Bank is designed and equipped to show some of the directions in which the cinema may develop in the future. It is arranged for the projection of television, stereoscopic motion pictures, and stereophonic sound to an audience of 400—requirements which posed new problems in cinema architecture. Another innovation to be seen in the Telecinema is the projection of an illuminated border, whereby the picture on the screen is surrounded, not by the usual black frame, but by a lighter fringe which changes in intensity and colour according to the average intensity and colour of the projected picture.

Present techniques have not yet reached the stage where it is possible to present a stereoscopic picture to a large audience without making some compromise between the ideal and the practicable; this compromise involves the wearing of some form of spectacles by the audience. Two methods of stereoscopic viewing through spectacles are possible, the first using two-colour spectacles, and the second perpendicularly polarised spectacles. As two-colour spectacles preclude the use of colour films, the polarised-light system has been adopted for the Telecinema.

Two images, maintained in horizontal and vertical register, are projected on to the screen by running two separate S/U/P/A film projectors in synchronism with one another, the light beam from each being suitably polarised by filters carried on the projectors. The resulting images on the screen, when viewed through polarising spectacles, give a very effective three-dimensional picture. Accurate synchronisation of the two projectors running side by side is accomplished by the use of Selsyn motors.

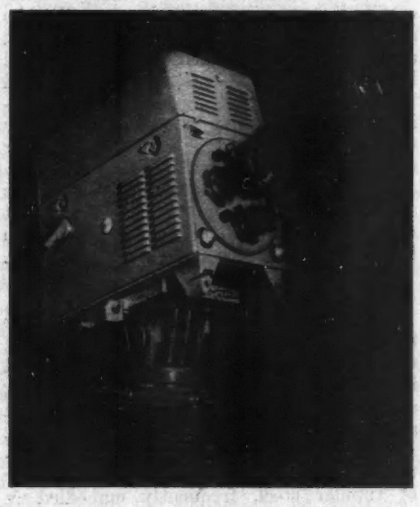
Stereophonic sound reproduction differs from conventional practice in that no sound is recorded on the films running through the picture projectors, but is, instead, recorded on a separate film coated with magnetic material for running through a separate sound reproducer head. A requirement of stereophonic sound is that there should be two or more completely separate sound channels and in this equipment three-channel stereophonic magnetic recording is employed. A fourth sound channel is used solely for sound effects reproduced from loudspeakers mounted in the main and balcony ceilings, and at the back of the auditorium. The sound from the three stereophonic tracks is reproduced from behind the screen, where there are three loudspeaker systems, each consisting of a standard S/U/P/A combination of twin-unit low-frequency horns and twin-unit high-frequency horns, with a change-over frequenyc of 500c/s. Each of the three "stereophonic" sound channels feeds one loudspeaker combination and the sound from the screen accompanies its apparent source on the screen. The screen loudspeakers are used not only for the reproduction of stereophonic sound, but also for monaural sound in conjunction with normal films, television sound and interval music.

In the development of the magnetic recording and reproducing system, the British Thomson-Houston Company, Ltd. (which was responsible for the film projection equipment), worked in close collaboration with Electrical and Musical Industries, Ltd., which provided the magnetic film, reproducer pick-up heads and pre-amplifiers for the scheme. To run the standard projectors with separate magnetic sound reproducers, Selsyn motors are again employed to maintain synchronism.

Another characteristic of the presentation of all the films at the Telecinema is a projected picture surround—a B.T.H. development from pre-war investigations into the possibility of providing an alternative to the black border which, it is felt, detracts from the appearance of the picture, but which is still the standard practice of the cinema industry. For optimum presentation of picture detail and colour, the picture should be presented against a neutral background such that the highlights on the screen are always brighter than the surroundings, and the dark portions of the picture always darker than the surroundings. These conditions can be satisfied by projecting the surround-lighting from the film projector itself in such a way that the intensity and colour of the surround takes on the average intensity and colour of the picture at all times.

In the B.T.H. projectors at the Telecinema this improvement is achieved, fairly simply, by making use of the light normally wasted during the pull-down period when the shutter is closed. A standard shutter, having a reflecting rear surface, is employed to reflect the normally wasted light on to a mirror and then through a special optical system on to the screen. This optical system contains masks to shape the light beam so that it only illuminates the surround. The scheme is completely independent of any manual control and results in a satisfactory background for film projection in cinemas.

A general view of the Telecinema projection room is reproduced herewith, showing the stereophonic sound reproducer heads on the left and the two synchronised S/U/P/A film projectors on the right. To give the public a view of all the television and film operating equipment in the Telecinema, the projection room has been specially designed with a glass screen overlooking the foyer of the building.



"IMAGE ORTHICON" TELEVISION CAMERA

The cinema television equipment was supplied by Cinema Television, Ltd., and the television cameras by Marconi's Wireless Telegraph Company, Ltd. The new Mark II camera embodies the "Image Orthicon"

pick-up tube and a four-lens rotatable turret, as illustrated herewith. The turret is controlled, from the rear of the camera, by the camera operator and the vision output is automatically blanked when the turret is rotated. Lens sizes range from 2in at f/1·9 to 25in at f/5, and include telephoto and Zoom lenses. An electronic viewfinder, which is clipped on the top of the camera, embodies a small vision monitor tube presenting to the operator a replica of the image that is being picked up by his camera. This electronic viewfinder eliminates the operating difficulties sometimes experienced with optical viewfinders under poor lighting conditions. Focusing is done by racking the camera tube and deflection assembly relatively to the lens, the necessary

TELEVISION PRODUCTION CONTROL CONSOLE

control being exercised through a single handwheel. All circuits for supplying the tube and deflection assembly, for raising the vision signal to transmission level, and for the camera control and h.t. supply unit are contained within the camera itself.

The complete television equipment is suitable either for mobile "outside broadcasting" stations or for studio use. For the sake of mobility, the installation is designed as a number of units each of which is carried in a separate portable case and transported in television vehicles. Special console housings enable the units to be set up quickly for studio use, and installations of any required size can be built up unit by unit.

A typical production control console is shown in one of our illustrations. A head-set is provided on the camera for communication between the operator and the control room.

The Exhibition Site

In concluding this series of articles on the South Bank Exhibition, it may be recalled that the buildings themselves were described in an article entitled "Structural Engineering at the South Bank Exhibition," which appeared in our issues of May 4th and 11th. An interesting point about the lighter structures at the exhibition is the extensive use of tubular steel, frequently embodied in welded space frames or trusses, or used, for instance, as columns to support a reinforced concrete canopy. Examples are those of the entrance canopies of the Royal Festival Hall and the mast on the Transport Pavilion, which carries a radar scanner at its top. This mast is 45ft in length, and its top is about 100ft above ground level. It is supported by guys, which have been prestressed for stability, following the same principle as the prestressing of the ropes of the Skylon, which was described in the article referred to above. The open-air display between the river wall and the Festival Hall is given adequate cover, whilst at the same time keeping free an essential promenade space, by a large canvas velarium supported by steel tubular masts and booms and rigged by wire ropes. Yet another instance is that of the "entrance features," which each consists of a tubular steel mast with wire ropes supporting an aluminium covering shaped in the fashion of a frustum of a cone.

There are two standardised bridges giving access to the site—the Bailey bridge across the Thames and a Callendar-Hamilton bridge of three spans giving access from Waterloo Station. An aluminium footbridge has also been built between the Minerals of the Island and the Power and Production pavilions. It has been fabricated from aluminium alloy extrusions, and has a span of nearly 70ft, being about 5ft by 7ft 6in in cross-section.

Western Region Gas Turbine Locomotive in Service

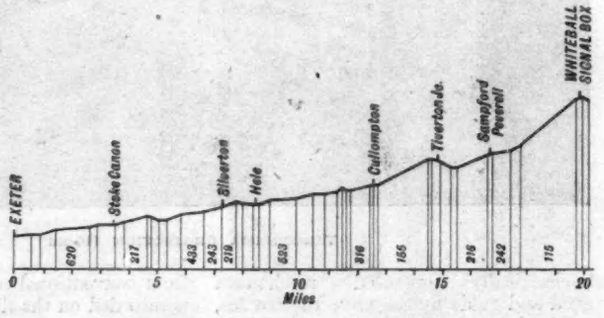
By O. S. NOCK, B.Sc., A.M.I.C.E., M.I.Mech.E.

DURING the past year the gas turbine locomotive No. 18,000 has made some notable runs in the working of Western Region express passenger train services. It is, of course, no secret that teething troubles have been experienced—indeed, it would have been most surprising if they had not; but on certain occasions the level of performance has been very high, sufficient to show the capabilities of the locomotive from the viewpoint of tractive power at speed. The economics of this experiment have yet to be determined and in reporting upon some of these recent runs it is important to emphasise that it is only as a haulage unit that the locomotive is considered. It must also be borne in mind that all these runs have been made under the close supervision of a particularly competent and enthusiastic locomotive inspector who has had the engine in his charge all the time. At the time of writing, drivers have not acquired sufficient familiarity with the new machine to assume sole charge and so far the availability of the locomotive has been limited accordingly.

The tractive effort of the locomotive, at wheels, is 31,500 lb up to about 21 m.p.h., 12,400 lb at 64 m.p.h., 8400 lb at 90 m.p.h.

Theoretically, therefore, the starting effort is approximately equal to a "Castle" class four-cylinder 4–6–0 express engine; at higher speeds the tractive effort approaches the optimum performance of the much larger four-cylinder 4–6–0s of the "King" class. In actual running it seems usual to start easily—generally slower than one would expect from a "Castle," but once the speed has risen above about 20 m.p.h. progress is usually very swift. It is true that some rapid accelerations from rest have been successfully made, after the power unit has been run up to speed while standing in the station and the traction motors have been cut in at a relatively high load. Similarly, some spectacular climbing of steep gradients has been achieved. From general experience with the locomotive, however, it has been found preferable to work up gradually, since the high-speed performance characteristics admit of easy recovery from any possible effects of a quiet start.

One performance noted by the author was on the 8.54 a.m. train from Exeter to Paddington. The normal mid-week load was carried: ten coaches, making, with passengers and luggage, a weight of approximately 345 tons behind the locomotive. This is, of course, not a heavy train by modern standards; but a late start of 4 min gave some opportunity of fast running over a stretch of line that is now in very fine condition. The gradients between Exeter and Whiteball tunnel are shown below. The start, over the 1·3 miles to Cowley Bridge Junction in 2 min 40 sec was of "Castle" quality and may be compared with a starting time of 2 min 58 sec by the steam locomotive No. 5098 "Clifford Castle," hauling 460 tons. After Stoke Canon, however, the speed of the gas turbine locomotive became unusually fast for this stretch of line and, inclusive of



GRADIENTS FROM EXETER TO WHITEBALL

an easing through Cullompton station, the average for 15 miles above Stoke Canon was 65 m.p.h., with a maximum of 71 m.p.h. near Tiverton Junction. Impetus carried the train up the final 2 miles at 1 in 115 without speed falling below 60 m.p.h. at the summit.

The time of 20 min 15 sec from Exeter start to passing the Whiteball signal-box (19·9 miles) must be regarded as an exceptional one to-day. The standard schedule time is 25 min, though on this booking the "Castle" class engines are rostered to haul a maximum tare load of 485 tons and the "King" class engines 530 tons tare. With heavy passenger loading, such as occurs with summer holiday trains from the West of England, the gross loads behind the tenders might easily rise to 530 tons and 580 tons respectively against the 345 tons handled so spectacularly by the gas turbine locomotive. After Whiteball summit the line falls steeply for 4 miles and then gradually flattens out towards Taunton. On the gas turbine locomotive power was shut off after the first mile of descent, but although coasting, a maximum

speed of 83 m.p.h. was obtained and Norton Fitzwarren station passed in 27 min 20 sec from the start, 28·8 miles. Taunton (30·8 miles) was reached in 29 min 44 sec, start to stop, and a departure from Exeter 4 min late had been converted into an arrival 4 min early.

The question will naturally be asked as to whether 4–6–0 steam locomotives of Great Western design could actually equal this uphill performance. Generally speaking, present-day schedules, like those of pre-war years, are such that very rapid climbing is not required on this ascent, and such that with trains leaving Exeter behind time recovery could be made under easier steam on more favourable stretches of the road. A search through earlier records, however, shows that in 1907 the late Charles Rous-Marten timed one of the earliest Churchward 4–6–0 engines, No. 4002, "Evening Star," to pass Whiteball box in 20 min 24 sec from the dead start at Exeter, with a load of 255 tons in the teeth of a heavy side gale. A calculation of the drawbar horsepower developed by the gas turbine locomotive shows about 1450 d.h.p. sustained at 67–68 m.p.h. on the Whiteball ascent, while by comparison engine No. 5098, "Clifford Castle," hauling 460 tons, sustained roughly the same d.h.p. at 61 m.p.h., while working in 24 per cent cut-off with full regulator.

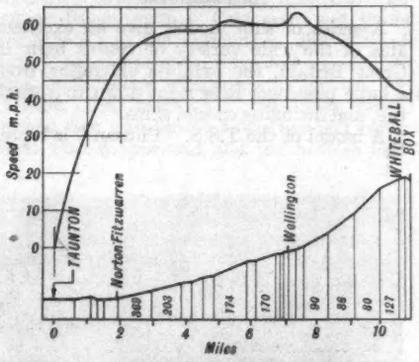
On the non-stop run of 142·7 miles from Taunton to Paddington, booked in 160 min, the gas turbine locomotive had an ample margin of time in hand at every stage. Harder work was required on a journey with the 3.30 p.m. westbound train from Paddington, allowed only 148 min for the same run, and with running conditions made still more difficult by two delays on the road. A signal delay caused an initial loss of 4 min as early as Southall while, on account of permanent way work at Heywood Road Junction, at the entrance to the Westbury by-pass line, the Weymouth slip-coach could not be detached there and a stop had to be made in Westbury station instead. Between them these two delays cost 10 min in running, yet the train reached Taunton in 146½ min from Paddington, 1½ min early. The train load was again no more than moderately heavy, being 415 tons to Westbury and 375 tons beyond, but the log in the accompanying table will indicate the nature of the speed maintained.

The stretches between Savernake and Lavington and between Castle Cary and Creech Junction are favourable and here maximum speeds slightly in excess of 80 m.p.h. were attained. The average speed of 64·7 m.p.h. between Theale and Bedwyn was made against an average rising gradient of about 1 in 500.

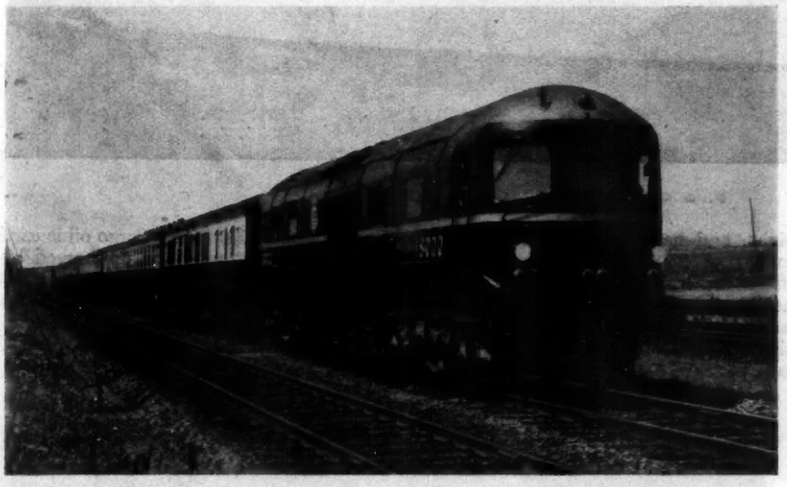
Log of Run from Paddington to Taunton

Miles			Time, min	Time, sec	Average speed, m.p.h.
0·0	Paddington	...	0	00	—
—			sig. checks		—
9·1	Southall	... ...	16	56	—
13·2	West Drayton	...	21	29	67·2
34·0	Milepost 34	...	40	02	
36·0	Reading	... ...	42	10	service slack
41·3	Theale	... ...	48	29	64·7
66·4	Bedwyn	... ...	71	44	
			curve slack		
70·1	Savernake	... ...	75	41	73·3
86·9	Lavington	... ...	89	24	
95·6	Westbury	...arr.	98	35	
		dep.	100	20	
108·5	Strap Lane	...	115	27	
115·4	Castle Cary	...	121	27	72·6
140·5	Creech Junction		142	13	
142·9	Taunton	...arr.	146	27	

On this heavy ascent although the intermediate work of the gas turbine engine was fast the overall time suffered from the slowness of the start. By comparison, one of the mixed traffic 4–6–0s of the "County" class, with a load of 380 tons, passed Whiteball in 14 min 24 sec. Speed did not rise above 56 m.p.h. at Wellington, fell to 42 m.p.h. at the tunnel entrance, and finally to 39½ m.p.h. before the summit. Of course, too much significance should not be attached to the starting effort of the gas turbine. But as there was a severe slowing for permanent way work to come west of Cullompton and those in the cab were keen on time-keeping, it seems unlikely that in running from Taunton to Norton Fitzwarren they would have dropped a full minute on steam standards without some good reason. As it was, despite the fine climb to Whiteball and fast downhill running before and after the Cullompton check, the time of 36¾ min from Taunton to Exeter (30·8 miles) was ¾ min over schedule.



GRADIENTS AND SPEEDS FROM TAUNTON TO WHITEBALL, LOAD 375 TONS



PLYMOUTH-PADDINGTON EXPRESS HAULED BY GAS TURBINE LOCOMOTIVE No. 18000

This timing, with its start-to-stop average of 51·3 m.p.h., is a fairly stiff one in consideration of the intermediate gradients. On longer non-stop runs the gas turbine locomotive, developing a power output approaching its high rated tractive force of more than 5 tons at 64 m.p.h., is capable of making average speeds with heavy trains at last equal to those made by the "Castle" class engines before the war. On runs with the West of England expresses the stretches of line over which maximum output is required are, however, relatively few, on account of the alternations of adverse and favourable gradients and an exceptional effort can be extracted from a steam locomotive for a short time at the expense of a drop in boiler pressure—which can readily be restored on the next favourable stretch. This is done with the "County" class engines on the road north of Wolverhampton. With the "Castles" I have several times seen the development of drawbar pulls slightly exceeding 4 tons at 60 m.p.h. without any loss of pressure, and once an estimated pull of 4·9 tons at 53 m.p.h. by engine No. 7036. So far as the gas turbine is concerned the observations set down in this article are in the nature of a preliminary survey and indicate something of its possibilities in train running when in expert hands. The more revealing test will come later, when engine crews have become sufficiently familiar with operating technique to go without the guidance of an inspector and when the locomotive is in general service.

ASSOCIATION OF SUPERVISING ELECTRICAL ENGINEERS.—At a recent meeting of the executive council of the Association of Supervising Electrical Engineers, Mr. W. F. Parker, M.I.E.E., was unanimously elected chairman of the Association of the year 1951–52. Mr. Parker is technical director of Troughton and Young, Ltd. Mr. L. L. Emmett was elected vice-chairman of the Association and Mr. E. J. Sutton was re-elected honorary treasurer.

Exhibition of Industrial Power at Kelvin Hall

No. VII—(*Continued from page 8, July 6th*)

IN the previous article we gave a general description of the exhibits to be seen in the hall; below we give further details of some of the items displayed.

Shipbuilding

A series of ship models give an excellent idea of the wide variety of vessels built in Great Britain, the exhibits extending from a large passenger liner right down to a small tug, and including special ships.

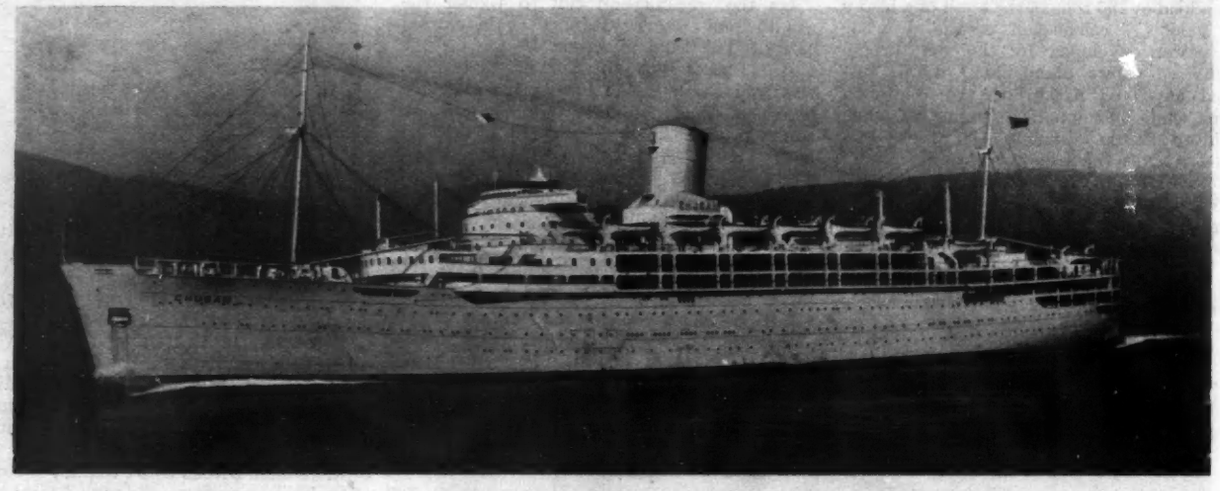
A model of the T.S.S. "Chusan" is representative of passenger liners and was the largest vessel completed in 1950. Our photograph shows the vessel leaving for trials. She has a length between perpendiculars of 630ft, a breadth moulded of 85ft, a depth moulded of 48ft, and a draught of 29ft, and was built and engined by Vickers-Armstrongs for the China and Far East run of the Peninsular and Oriental Steam Navigation Company, Ltd. The ship has accommodation for 475 first-class and 551 tourist-class passengers and is driven at 22 knots by twin-screw double reduction geared turbines, of Pametrada design, developing a normal power of 34,000 s.h.p. at 130 propeller revolutions per minute. Steam is supplied by four Foster-Wheeler controlled superheat boilers at 525 lb per square inch, and 850 deg. Fah., and the electrical load is met by four British Thomson-Houston turbo-generators each rated at 850kW, 220V d.c. The passenger comfort in "Chusan" was increased by reducing the amplitude of roll, in adverse weather, through the use of Denny-Brown hydrofin stabilisers,—the first installation of its kind in a large ship.

The "Rangitane," completed in 1949 by John Brown and Co., Ltd., for the New Zealand Shipping Company, Ltd., is an example of a high-class passenger and cargo liner. This ship has the following particulars:—length between perpendiculars 575ft; breadth moulded 78ft; depth moulded 53 ft; load draught 32ft; service speed 17 knots; and an insulated capacity of 505,000 cubic feet. The vessel has one-class accommodation for about 400 passengers, and is propelled by two sets of Brown-Doxford oil engines. Each engine has six cylinders, 725mm diameter by 2250mm combined stroke, and develops 6950 b.h.p. at 114 r.p.m. Electrical power is supplied by four W. H. Allen diesel generators, each set consisting of an eight-cylinder, two-stroke engine with an output of 960 b.h.p. at 333 r.p.m., direct-coupled to a 640kW, 220V d.c. generator.

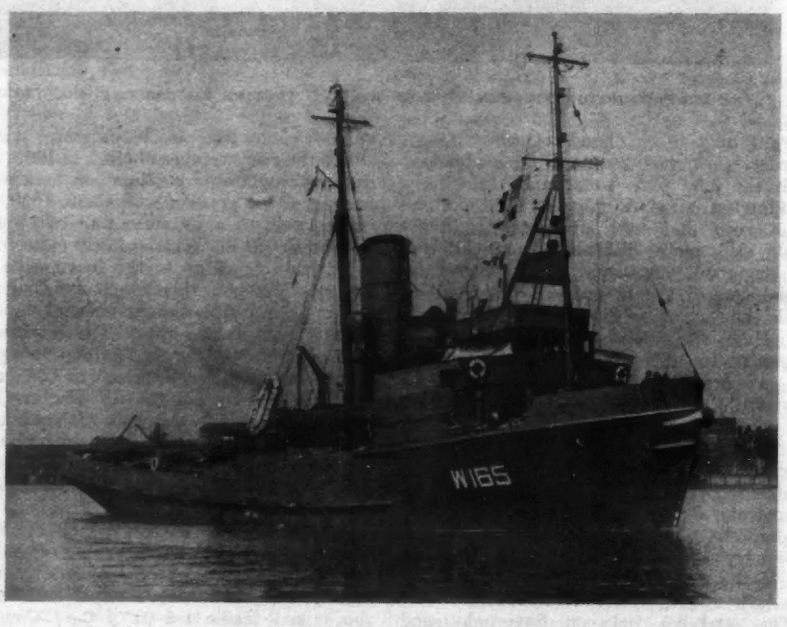
The "Cubahama," built to the order of the Bahama Line, by Henry Robb, Ltd., is a twin-screw motorship of 1000 tons dead-weight, and has a length between perpendiculars of 250ft, a breadth moulded of 38ft and depth moulded to the shelter deck 21ft. The ship is of flush shelter-deck design with machinery aft and two large holds. Two British Polar two-stroke seven-cylinder diesel engines, each developing 1120 b.h.p., at 250 r.p.m., give the vessel a speed of 15 knots, and there are three 40kW, 220V generators, driven by Ruston and Hornsby diesel engines developing 62 b.h.p. at 900 r.p.m.

Our second photograph is of H.M.R.T. "Envoy," a model of which is exhibited. The vessel was built for special towage, rescue, salvage and fire-fighting purposes during the last war for the Admiralty by Cochrane and Sons, Ltd. Her dimensions are 160ft length between perpendiculars, by 34ft 6in beam, by 16ft 6in depth, and she is powered by a triple engine of 1700 i.h.p., taking steam from two cylindrical boilers, which gives the tug a speed of 13 knots.

There is a model of the oil tanker the "Polartank," which was constructed by Barclay, Curle and Co., Ltd., for Norwegian owners. The vessel has dimensions 566ft by 72ft 6in by 40ft 6in, and carries a dead-weight of 19,000 tons. Cargo oil is carried in twenty-seven tanks and discharged by four steam pumps in two pump rooms, the steam being supplied from two cylindrical multi-tubular composite boilers. The propelling machinery is of the current Barclay Curle-Doxford design and is the largest opposed



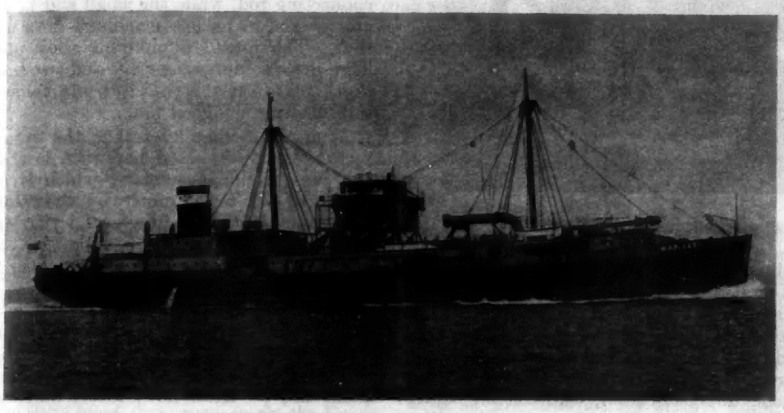
P. & O. Liner "Chusan"



H.M.R.T. "Envoy"

piston airless injection engine built, having six cylinders, 750mm diameter by 2500mm combined stroke.

One of the special vessels exhibited is a model of a diesel-electric dredger, "M.O.P. 225-C," which was built for the Argentine Government by Fleming and Ferguson, Ltd., and is shown in our photograph, She has a length between perpendiculars of 290ft by 58ft beam by 19ft depth and a loaded draught of



DIESEL-ELECTRIC DREDGER "M.O.P. 225-C"

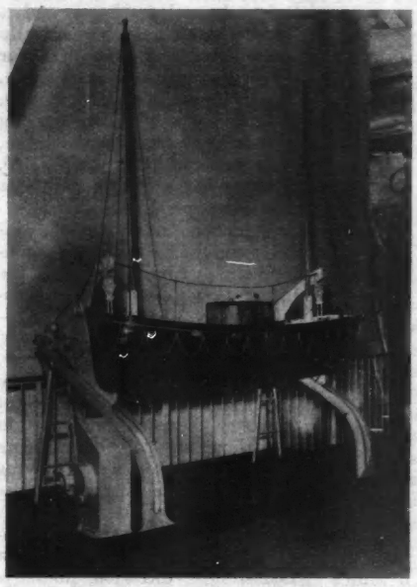
12ft 1½in, while the maximum dredging depth is 49ft 3in and the hopper capacity 1764 tons. The vessel is driven at 11¼ knots by two 1500 s.h.p., 440V propulsion motors, running at 250 r.p.m., and taking power from four 690/704kW., 225/230V d.c. generators, each driven by a twelve-cylinder 45 deg. vee-form four-stroke pressure-charged diesel engine, developing 1020 b.h.p., at 700 r.p.m. Dredging equipment includes a 39in diameter

SHIP'S ENGINE-ROOM

suction pipe, supported in a ladder swinging from trunnion centres and two dredge pumps, each rated 830 b.h.p. at 195 r.p.m. The English Electric Company, Ltd., designed and manufactured the complete diesel-electric equipment, which also included four auxiliary diesel generator sets, each consisting of a six-cylinder engine, with an output of 225 b.h.p., at 550 r.p.m., driving a flange-mounted 150kW, 220V d.c. generator.

At ground level in the three-deck structure in the middle of the hall, the space is arranged as a mock-up of an engine-room, equipped with oil engines. The main propulsion unit is a Mirrless, Bickerton and Day eight-cylinder, four-stroke, airless injection oil engine, developing 720 b.h.p., at 300 r.p.m., and which can be seen in our illustration. The rigid box-section bedplate is of cast iron, with an oil sump at one end; the columns are also of cast iron and the large access doors allow the piston and connecting rod to be withdrawn downward without disturbing the cylinder head. Each cylinder, of 13¾in diameter by 21in stroke, is fitted with a wet liner, fixed at the top and free to expand downwards and close-grain cast iron cylinder heads incorporate air and exhaust passages and a centrally-placed fuel valve. A separate fuel injection pump is fitted to each cylinder and driven direct from the camshaft, the fuel oil being injected into a combustion chamber formed in the piston crown. The pistons have four pressure rings and one scraper ring, and floating gudgeon pins, while the connecting rods have small end bearings of bronze and big end bearings lined with white metal. The crankshaft main bearings are steel, white metal lined, and the thrust bearing is backed with bronze. A Michell water-cooled thrust block is incorporated with the engine, and starting is by compressed air at 300 lb per square inch.

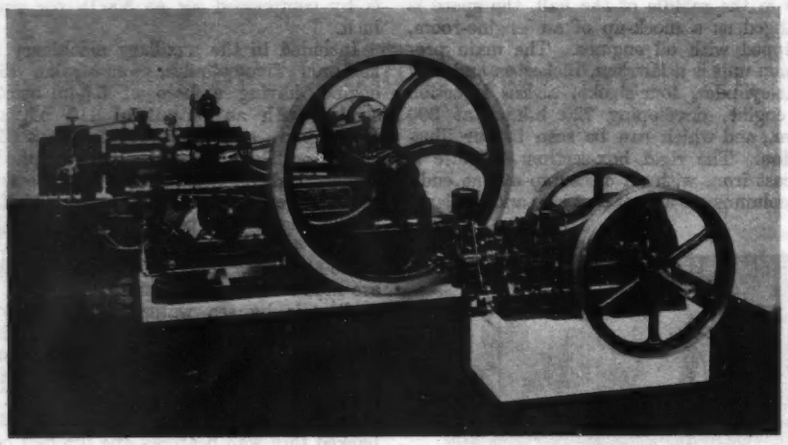
Included in the auxiliary machinery is a McLaren five-cylinder, four-stroke, diesel engine, having a bore of 5 9/16in by 7⅞in stroke, with an output of 110 b.h.p. at 1000 r.p.m., and direct coupled to a 65kW generator. There are two engines supplied by Petters, Ltd., one driving a generator, compressors and general service pump set. This four-stroke engine has two cylinders of 3·15in bore by 4·33in stroke and develops 10 b.h.p. at 1500 r.p.m. The engine and auxiliaries are mounted on a rigid steel base-plate, and cooling is by sea water circulated by an engine-driven pump. Cast iron wet liners are fitted, and the aluminium alloy pistons have three compression rings and one scraper ring, and floating gudgeon pins located by Circlips. The connecting rods have steel-backed thin wall bearings, the top half being lined with copper-lead and the bottom half



MOTOR LIFEBOAT AND DAVITS

with white metal, which is also used for the main bearings. The generator is a drip-proof, compound-wound d.c. machine, rated at 5kW, and driven through a flexible coupling. An extension of the engine camshaft drives the water-cooled single-stage compressor, having a free air delivery of 7 cubic feet per minute, and capable of operating against a maximum pressure of 350 lb per square inch for charging duties. The general service horizontal single-stage centrifugal pump, when running at 1500 r.p.m., delivers 80 gallons per minute against a total head of 35ft, and has a cast iron casing, cover and head stock, gunmetal impeller and stainless steel shaft running in ring-oiled bearings.

Life-saving at sea is exemplified by a model, to one-third full size, which we illustrate, of a lifeboat suspended in a set of davits. The boat, which is a model of a statutory 28ft motor lifeboat, was built in African mahogany by Watercraft, Ltd., of East Molesey, and is equipped with a wireless cabin. The full-size lifeboat is driven by a 20 h.p. Ailsa Craig diesel engine, has a capacity of 35 persons, a light weight of 6 tons and a loaded weight of about 8 tons. The davit set is a model of a standard 8¼-ton working load, Welin-Maclachlan overhead gravity davit, which is operated by a 10 h.p. electric winch, having a rate of hoist of approximately 20ft per minute. The davits



HORNSBY-AKROYD ENGINE AND ITS MODERN COUNTERPART

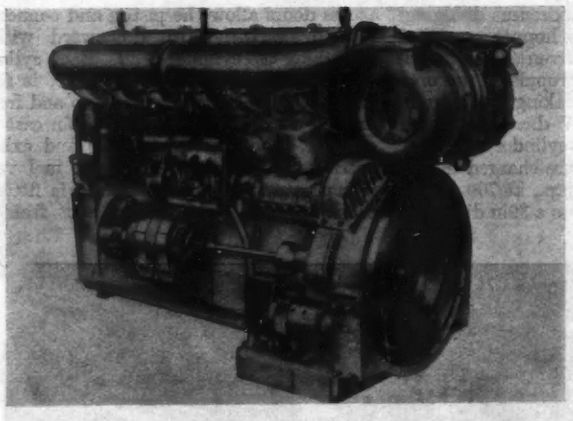
have a built-up channel trackway and a box-section cradle, which is hermetically sealed to prevent internal rusting. Tubular "A" frames, which occupy little deck space, support the inboard ends of the trackways. The winch motor is coupled to gearing through an automatic centrifugal clutch, and the winch is mounted at the ship's side, so that the operator has a clear view of the hoisting and lowering operations.

Among the marine navigational aids there are echo-sounding and direction-finding equipments, produced by the Marconi International Marine Communications Company, Ltd. The echo-sounding display is based on echometers, instruments which emit pulses of energy, measure the time taken for each pulse to reach the sea-bed and return, and then present the depth of water beneath the ship in readable form without any calculation being necessary. The display shows a ship moving across a panel and at certain points a pulse can be seen leaving the projector in the ship's bottom and being echoed back from the sea-bed. The direction-finding display shows how a ship's "Lodestone" direction finder is used to determine her position by radio in poor visibility. Radio beacon stations ashore transmit at fixed intervals and, by ascertaining the direction from which these signals are coming the navigator can get a "fix," which is the intersection of two or more bearings, and so pinpoint the position of the ship. Three radio beacon stations are shown in the display, each of which transmits its characteristic signal in flashing light and sound. An arrow on a dial, marked in degrees, moves to the direction of the station and gives the bearing; cross bearings are taken on transmissions of the other two stations and a "fix" obtained.

Railways

This section of the exhibition opens with the original Hornsby-Akroyd oil engine, believed to be the first oil engine power unit to run with commercial success. This unit was built at the Grantham works of Richard Hornsby in 1892, and continued to function excellently in the service of the Fenny Statford Waterworks until 1923. From then until 1939 the engine provided the power for driving saw-mill machinery and then was brought back to Ruston and Hornsby in honourable retirement, and for historical record and interest. The engine is shown in our photograph, and alongside it can be seen its modern counterpart—a 10 h.p horizontal oil engine produced by the same firm. Another product of the company, which is exhibited nearby is a diesel mechanical shunting locomotive. It is of 165 h.p., weighs 28 tons, has an 0–4–0 wheel arrangement and is used for shunting duties on the sidings of industrial works.

Henry Meadows, Ltd., has on view a Mark 970, six-cylinder turbo-charged, four-stroke, direct-injection, cold-starting, water-cooled, compression-ignition oil engine, illustrated herewith. It has an output of 270 b.h.p. at 1650 r.p.m., and is used for heavy road or rail traction duties. The crankcase is a high grade iron casting of rigid design, and there are two detachable cast iron cylinder blocks, each having three cylinder bores, in which are fitted wet liners, centrifugally-cast in high duty alloy iron. High grade cast iron is employed for the two cylinder head units, which have fitted to them renewable valve seat inserts for the two inlet and exhaust valves. The valves are operated by primary and secondary rockers, actuated by tubular push rods having bucket pattern tappets controlled by a seven-bearing camshaft. A nitride hardened crankshaft is provided and has seven main bearings, all of which are of the thin shell steel-backed pattern. This design is fitted to the big end bearings of the "H" section connecting rod, while the small end bearings are pressed in bushes machined after insertion. The forged aluminium alloy pistons have three compression rings and two scraper rings, placed one above and one below the fully floating gudgeon pin.



SUPERCHARGED RAIL-TRACTION DIESEL ENGINE

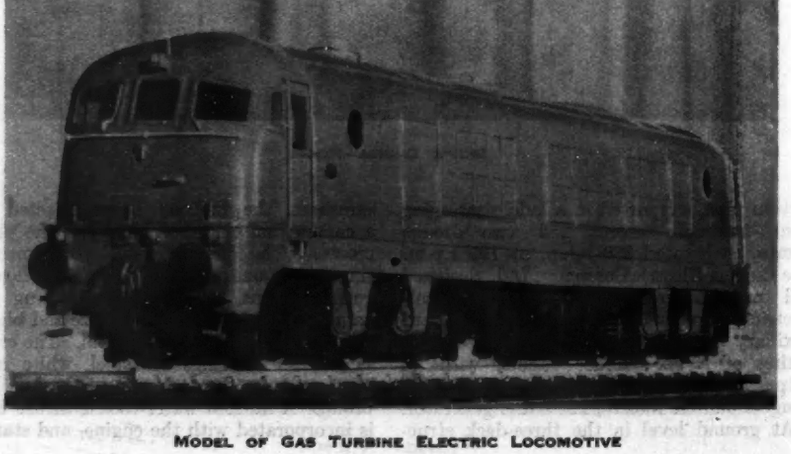
A model of some interest in the transport section, and illustrated herewith, is that of the gas turbine locomotive, which is being designed and built jointly by the Western Region of British Railways and the Metropolitan-Vickers Electrical Company, Ltd. According to early statements, this new locomotive will have a maximum tractive effort of 60,000 lb, with a continuous tractive effort of 29,000 lb, and will be capable of speeds up to 90 m.p.h.

The three main components of the thermal plant are an axial flow, fifteen-stage compressor, a flame tube combustion chamber, with six flame tubes, and a five-stage axial flow turbine. The output is 35 per cent of the power produced by the turbine, the compressor unit absorbing the other 65 per cent.

The turbine output is absorbed in three main generators, an auxiliary generator and an exciter, all of which run at 1600 r.p.m. at full load. Each main generator supplies current to two axle-mounted motors, which drive their axles through single reduction spur gears.

Another model shows one of the 3000 h.p., 3000V d.c. main line electric locomotives, built for the Sao Paulo Railway Company by the English Electric Company, Ltd., and the Vulcan Foundry, Ltd. These locomotives each weigh 120 tons, and are capable of hauling a 600-ton train at 45 m.p.h. on the level, and double headed trains of 500 tons at 60 m.p.h.

The Vulcan Foundry, Ltd., is also showing



MODEL OF GAS TURBINE ELECTRIC LOCOMOTIVE

a model of its "River" class, 3ft 6in gauge, steam locomotives for the Nigerian Railway. These engines weigh about 71½ tons, and at 90 per cent boiler pressure have a tractive effort of 31,550 lb.

The final exhibit in the railway section is the model railway system measuring 30ft by 15ft. The lay-out is accurately signalled, with coloured light signals, in accordance with full-size practice, and has a complete electrical installation. Current for the locomotives, which work on 20V d.c., is supplied from a.c. mains through rectifiers and the d.c. current is fed to the control panel through two 6V 36W bulbs, which act as fuses. The control box is divided into panels to operate the various track systems, upon which run a wide selection of locomotives, the rolling stock used including many passenger and freight trains.

(To be continued)

International Conference of Naval Architects and Marine Engineers

No. II—*(Continued from page 25, July 6th)*

ON Wednesday, June 27th, the first paper to be taken was:

HIGHER STEAM CONDITIONS FOR SHIPS' MACHINERY

By M. L. Ireland, Jr., H. W. Semar, and N. L. Mochel

The paper deals with the problems in the selection and application of cycle components and high-temperature materials confined to the geared turbine drive based upon conditions in the United States. Advances in steam conditions require a balance to be struck between fuel savings, weight-saving and increased first cost, and various aspects of suitable steam conditions are considered. The selection of machinery components is considered, the factors concerning feed temperatures are touched upon, and also the steam conditions for auxiliary turbine drives. For pressures exceeding 600 lb per square inch an interesting development is the double compound feed pump having two high-speed impellers operated in series. Heat cycle diagrams for 12,500 s.h.p. and 40,000 s.h.p. machinery are given.

The phenomenon of creep, common to parts exposed to higher temperatures, is discussed and its bearing upon working stress and factors of safety. Hoop stress formulæ are given, the metallurgical significance of stress margins mentioned, and the allowances for corrosion and thinning at bends dealt with. Alloys for specific applications receive attention, and the paper has something to say about combined thermal and pressure stresses, thermal shock, and vibratory stresses.

Structural and fabrication problems concerning steam piping and the heat-treatment of welded piping are touched upon, together with questions about control equipment, operation and boiler efficiency.

Discussion

Vice-Admiral (E.) The Hon. D. C. Maxwell, (British Admiralty): It is necessary to appreciate that naval machinery designs differ basically from those to meet mercantile requirements. One essential difference is that naval machinery is utilised at full or high power for only a very small proportion of its life, and therefore we are prepared to sacrifice some full-load efficiency to obtain optimum part-load performance. In the section dealing with control of equipment and operating problems the authors state that a steam temperature characteristic rising with boiler output is very desirable. In some naval designs we call for higher steam temperature at the lower powers in order to obtain the best possible efficiency at cruising speed; full use can thus be made of the fact that centrifugal stresses are much reduced below full power. A boiler characteristic of this type requires control of steam temperature, and this allows the temperature to be greatly reduced during manœuvring and whenever there are considerable, and more particularly rapid, changes in power. Naval designs are largely controlled by considerations of space, for it is only by making every effort to minimise the space occupied by equipment that the best battle characteristics can be worked into the overall ship design. In turbines this has led to the use of high blade speeds, with by-passed stages in the h.p. turbine and high leaving losses from the l.p. turbine. The authors have pointed out that with high-temperature designs, by-passing of the initial stages of the h.p. turbine introduces difficulties in design. The alternatives involve additional space and weight, and for naval purposes this must be carefully balanced against the improved efficiency of the cycle. Almost as important as the bulk of the machinery is the requirement for minimum weight of machinery plus fuel, and in some cases it pays us to design for 25in or 26in vacuum at full power instead of the 28½in normal in the merchant service. The saving in weight of condenser and turbine allows more fuel to be carried and increases the ship's radius of action, while at the lower powers at which we normally operate a high vacuum is readily obtained. Should we go to higher steam temperatures without greatly increasing the steam pressure, the l.p. turbine exhaust is likely to be considerably superheated; we have so far not located any positive evidence of the effect of this upon condenser design, and I would welcome any experience the authors may have in this respect. Little has been done in naval engineering in the way of multi-stage bleed feed heating, owing to the weight of the heaters and pipes involved, and to some extent to the complications which may arise when frequently changing power. Naval practice is to use non-condensing steam-driven auxiliaries, the exhaust from which is used for feed heating either in a pressure heater or de-aerator. This affords the equivalent of single-stage bleed feed heating, while preserving the essential lightness of the installation.

The use of higher steam temperatures poses a considerable problem in the lay-out of auxiliaries, due to the complication of the steam and particularly of the exhaust pipes from these auxiliaries. The common solution in the merchant service is to use electric drive for all but the largest auxiliaries, but this as a complete solution is not so attractive to us because of the danger of interruption to electric supplies during battle. One more difference between mercantile and naval practice in design is that of cost. In merchant ship work, first costs, operating costs and maintenance costs are three guiding principles in deciding steam conditions. In the naval design we have to be certain that the taxpayer gets value for money, value in this case being the military qualities of the ship. But we must also consider cost as being a yardstick of the effort required to produce, as manpower is the biggest single limitation in our country's effort in war. Not only must we reject a design which involves unduly complicated techniques, provided a less complicated design will serve the purpose, but we must ensure that our designs in peace do not call for materials upon which we cannot lay our hands in time of war. Stockpiling cannot be relied upon as a full solution of a supply problem, and we may find that we have to limit ourselves in steam conditions because of the danger of material shortages.

Mr. A. R. Gatewood (U.S.A.): There have been numerous references to the A.B.S. Interim Guide, so that it would seem appropriate to point out cases in which subsequent investigations have shown it desirable to modify the recommendations. The recommendation that circularity of the pipes in the way of bends be maintained within 2 per cent was found to be somewhat restrictive from the practical point of view; out-of-roundness results in purely localised stress which will relieve itself very rapidly as the pipe is put into service. In some cases combined stresses may result in out-of-roundness of as much as 9 per cent, and since it is not desirable to encourage poor workmanship, we have now recommended that the circularity of piping be maintained within 5 per cent, a figure which can easily be met.

Dr. T. W. F. Brown (Great Britain): As the paper deals specifically with geared steam turbines for marine propulsion, perhaps some mention of gearing might be made. It could be objected that gearing is not greatly affected by advanced steam conditions; but that, of course, is not so, because with advanced steam conditions there is greater heat drop to be dealt with in the turbines, and if the turbines are to be kept small they must revolve even faster than before, and the gearing has to carry a greater reduction ratio. As against this, in America and in this country, vast improvements in gear cutting have been effected. I would ask the authors how these two factors are married in advanced designs, i.e., the ability to effect greater reduction ratios in the boxes, and at the same time the reduction in box weight in relation to the higher loadings that can be carried. There is in the paper a diagram giving ranges of steam conditions for various shaft horsepowers, and the authors refer to the conditions there indicated having been chosen to meet the increasing diesel competition. In this country the position is exactly the opposite. Particularly in tanker work it is the steam turbine which is slowly ousting the direct-coupled diesel engine, even in powers which are easily within the capabilities of the direct-coupled diesel engine, although, of course, in the monster tankers which are beginning to come in, single-screw steam turbine machinery is being used at powers for which direct-coupled diesel engines, at any rate in the single-screw form, could not be used. With regard to materials, particularly applying to superheaters, the authors do not refer to vanadium attack. We are still not sure whether it comes as vanadium pentoxide, sodium vanadate or some other compound, but we are certain that even in austenitic materials, if the surface of the tubes is at a temperature of the order of 1200 deg. Fah., it will be destroyed. There are no high-temperature alloys in common use which resist this form of attack, and until the question is solved it gives a practical upper limit to the steam temperatures which can be used in turbine machinery. I am very glad that, in regard to materials for turbine parts, the authors refer to the entirely successful experience with low-carbon, 12

per cent chromium steel. This corresponds to the stainless iron which we in this country so strongly recommend for turbine blades and nozzles.

Mr. L. Baker (Great Britain): In this country we have as yet little experience of the risk of thermal shock with advanced steam conditions, and as cautious engineers we must pay attention to that matter. Fluctuations of temperature must arise in service, and there is always the risk of either water or salt carry-over into the steam lines. The data so far published suggests that 1200 lb per square inch is the point at which the solution of the solids directly in the steam becomes important. On the other hand, in the past we have had experience of the deposition of solids selectively. With these points in mind, we have fitted in our new steamers special detection devices to eliminate as far as practicable the risk of damage due either to water or solids. I agree entirely with the authors that the correct procedure is to take one step beyond the economic optimum. The life of ships in Great Britain is at least twenty-five years and frequently considerably longer, so that if a ship is to earn any income at all in the later years of its life it must at least be up to present-day practice at its time of building, and preferably in advance of it, so that in its later life it can meet the competition of newer fleets.

Mr. H. N. Pemberton (Great Britain): The authors point out that the major incentive for advances in steam conditions of commercial vessels is the prospect of reduced fuel consumption. Several ships have been built in the United Kingdom in recent years having turbines operating at around 600 lb per square inch steam pressure and 800 deg. to 850 deg. Fah. With provision for steam reheat, a fuel consumption for propulsion in the region of ½ lb per shaft horsepower per hour can be obtained. Those installations are not particularly complicated, and in general the steam piping has been of plain carbon steel, a few pipe lengths in ½ per cent molybdenum steel being used in certain cases. We regard these ships as modern and their owners have no reason to be dissatisfied with their performance; moreover, they are proving reliable. One wonders, therefore, when studying the paper and pondering on the multitude of problems mentioned therein, how much further we might expect to go. The shipowner has little interest in pioneering advances in steam conditions beyond those which have proved to be thoroughly reliable, and which permit him to burn the cheapest form of fuel oil at a reasonable rate of consumption. My own view is that there will be a period of consolidation at figures approximating to those I have mentioned. No doubt, however, there will be further advances in marine plant, if only because in the long run marine practice is bound to follow land practice, and it will become increasingly necessary to compete with the gas turbine for high powers in the years to come. In the circumstances, whether we like it or not, we must face the problems associated with more advanced steam conditions at temperatures of more than 1000 deg. Fah. I think we British marine engineers can admit that we use mild steel for steam pipes in a somewhat extravagant way. Permissible working stresses are lower than they need be, but this unnecessary weight of material is not of primary importance and, indeed, is probably partly responsible for the fact that steam pipe failures in ships are extremely rare. With the higher stress conditions now contemplated, we cannot afford such extravagance in materials, however, not only because of the higher cost of the steel alloys required, but also because thermal conditions demand that the piping be as thin as possible, consistent with strength and safety. Allowable stress figures, as recommended in the Interim Guide issued by the American Bureau of Standards, are based on values for rupture strength extrapolated from the results of 1000-hour creep tests. The authors have referred to the dangers of extrapolated values which take no account of deterioration in material exposed to temperature and stress over periods much longer than 1000 hours. With this in mind, I would ask on what type of creep tests these recommended stresses are based. Dr. R. W. Bailey, one of our foremost British authorities on creep testing, has on more than one occasion pointed out that 1000-hour creep tests at the working temperature, using stress to accelerate creep strain, bring into account only to an insignificant extent the influence of thermal action on the material, whereas his method of testing at the working stress and using temperature as the creep-accelerating factor brings the thermal action more adequately into account. I do not dispute the allowable stress figures put forward in the paper; but before applying them we should know on what data they are based, and I should wish to be satisfied that the extrapolations were derived from creep tests conforming to the principles expounded by Dr. Bailey.

Mr. Ireland replied briefly to the discussion.

The next paper was:

BOILER AND TURBINE TESTING

by Captain (E.) L. F. Ingram, R.N., and Captain (E.) L. A. B. Pelle, D.S.O., M.V.O., R.N.

Synopsis

The four categories of machinery testing are defined and the advantages of trials, both ashore and afloat, discussed; data from trials ashore form the basis of the paper. Testing facilities at the Admiralty are mentioned and the work, equipment and activities of six stations are briefly reviewed. "Daring" class destroyer boiler trials are described stage by stage, including a circulation check to establish whether the boiler can develop full power supply, combustion, reliability, flexibility and handling tests, and the solution of the dryness problem. Oil burning equipment receives considerable attention and refractories are generally discussed, and also the effort to obtain a specification to ensure the greatest resistance to the spalling and slagging of firebricks.

The main features of the "Daring" turbine trials, which were fully instrumented, are noted and details of the astern trials given, including the hog measurements of the l.p. turbine. Blade axial clearances of the h.p. turbine during manœuvring trials are recorded and also rotor bore and h.p. turbine temperatures. Some of the teething troubles are listed and special reference is made to bearing temperatures and flexible couplings.

A section of the paper mentions gas turbine testing mainly with regard to the Gatric turbine in M.G.B. "P.5559," and the tests using boiler fuel. Concerning the testing of gears it is stated that investigations are directed towards machine accuracy and improved materials, the object being to produce gearing of minimum weight allied with reliability.

Discussion

Mr. J. H. King (U.S.A.): I was particularly pleased to note that the authors use the term "factors of ignorance." I wish that more people would look at the so-called factor of safety in that light, because as we learn more and more about materials, designs and so forth, that factor of ignorance diminishes. It is sometimes difficult, however, to obtain approval of lower so-called factors of safety, so that if we could consider this as really a factor of ignorance, actually as our ignorance diminishes so should the factor. For example, we are accustomed to calculate the hoop stresses in the design of a drum. We now add to that the calculations on out-of-roundness. Certainly this latter information removes some of the ignorance and should, I believe, lower the factor of safety. In regard to the historical section of the paper, we on our side feel that the introduction of welding was a development of outstanding importance, in that it made possible the development of boilers of higher pressures. The United States Navy furnished the incentive to the development of welding by private industry and, in fact, in 1930 gave final approval to a specification and method of welding boiler drums. The first such drums were subsequently installed in the U.S. cruisers "Minneapolis," "New Orleans" and "Astoria." Since that time all boiler drums in the U.S. Navy, and also in the U.S. Merchant Marine, have been welded. Most of our development work in America has been done by private industry. Our Navy furnishes the incentive by setting forth general requirements, but the actual development of new and advanced designs and the construction thereof is done by industry, subject to final approval by our Navy Department.

We have not very much difficulty with oil fuel contamination by water. Our principal difficulty at present has to do with the constituents of the oil, such as vanadium, sulphur and other minerals.

Dr. S. Livingston Smith, C.B.E. (Director, British Shipbuilding Research Association): The section of the paper dealing with the astern and manœuvring trials of the "Daring" class machinery is of especial interest. So far as I am aware, this is the first time that such data has been published, and it should prove invaluable to designers. It should also convince the most sceptical of the great value of full-scale testing ashore of prototype machinery. That is the only way in which to obtain accurate information. I was interested in the section of the paper dealing with refractories, since this is a problem which exists in a fairly acute form in many merchant ships, and in consequence the British Shipbuilding Research Association is engaged in a fact-finding investigation involving the examination of boiler brickwork in a large number of merchant ships. From this investigation we should be able to define the problem more exactly as it affects the merchant marine, with the ultimate object of improving brickwork life. The Admiralty appears to have devoted its main effort to tightening up the specification for firebricks, and so far as naval boilers are concerned this may well be justified. So far as the merchant marine is concerned, however, it seems that the questions of boiler operation (or mal-operation) and brickwork design are equally, if not more, important than the actual material used. I note with interest that the Admiralty have recently concluded that no advantage is to be gained by increasing the alumina content of firebricks beyond 43 per cent, since I believe that at one time they were considering the use of bricks having an alumina content of about 60 per cent. It is particularly fortunate that they have come to this conclusion, since the material required for bricks having an alumina content greater than approximately 43 per cent has to be imported. The clays in this country are mostly suitable only for the manufacture of refractories containing 30 to 37 per cent alumina, whilst only a small proportion can be used for firebricks containing 41 to 45 per cent alumina. Incidentally, it has long been appreciated that specifications of alumina content mean little as regards refractoriness, so that I am not surprised that this has been omitted from the latest

Admiralty specifications and replaced by the more logical pyrometric cone equivalent, together with more rigid specifications covering porosity and contained fluxes.

Dr. T. W. F. Brown (Great Britain): I thank the authors for their references to the instrument section at PAMETRADA. To some extent that section is rather the Cinderella; but if you pay for the complete installation of half an engine-room and half a boiler-room, and burn vast quantities of fuel, you will find that the comparative cost of the instrument section is extraordinarily small and that it may enable investigations to be carried out while routine tests are running. In fact, it was the instrument section which allowed some of the very severe manœuvring trials to be carried out, because one of the instruments produced was an axial clearance gauge which measured differential expansion between rotors and casing at the end of the turbine cylinder remote from the thrust block, and many of the manœuvres were, in fact, controlled by the taking up of clearances. It also enabled anything that appeared to be going wrong to be put right before severe trouble ensued. The total running time of the three sets which were tested amounted to about 1000 hours; had the machinery been installed on board a vessel, that would have represented more than the circuit of the globe. It is in the light of such figures that the costs should be examined, because I suggest that no one could possibly have carried out ship trials of that duration, and even if they had been carried out, the accuracy of the results would have been very far short of that achieved in shore testing. In specific fuel consumption or water rates the accuracy was of the order of $\pm\frac{1}{4}$ per cent. The very best that could have been achieved at sea is ± 2 per cent.

Mr. L. Baker (Great Britain): At a time when stability of steaming conditions may well be forced upon us, it is well that we should survey the research facilities that are available. They are paid for by the taxpayer and the shipowners. What are the benefits that accrue to those who pay for these enterprises? The taxpayer is clearly assured of the most efficient Navy that can be produced, and I can speak with feeling when I say that that was not so before the last war. Secondly, the shipowner benefits because the knowledge gained is circulated either through the people working on the various projects or by the presentation of data in technical papers such as this, so that such contributions are most valuable. The need for lighter and more compact machinery is just as pressing in the merchant navy as in the Royal Navy. As an illustration, comparing steam and diesel machinery, the diesel engine saves about 25 per cent in fuel, but it weighs about 30 per cent more and occupies about 15 per cent more engine-room length. At 7500 s.h.p. these three factors are approximately in balance when considering the ship as a means of carrying cargo economically. The third benefit is that the Admiralty has aided the shipowner by releasing, for civilian manufacture, designs of equipment originally produced for Service needs. Radar was an obvious application; but so far as marine engineers are concerned the release of Admiralty-designed oil fuel burning equipment is most important. As one of the well-satisfied users I am extremely grateful for this wise and helpful decision; by equipping our ships with this type of equipment we are saving no less than £25,000 per annum in fuel costs.

Mr. M. L. Ireland (U.S.A.): This paper is excellent and stimulating. In the paper itself, however, the remarks on ship trials were inclined to be discouraging, and Dr. Brown, in the discussion, has quoted an accuracy range, with which I agree, of ± 2 per cent as the best that can be expected on ship trials. Nevertheless, his remarks emphasise the desirability of running modest trials and obtaining as much information as possible from them.

Captain Peile made a brief reply and the conference adjourned until Thursday.

(To be continued)

The Automatic Digital Computer at Manchester University

No. I

A WEEK ago we attended a Press preview of a new high-speed automatic digital computer, which is an engineered version of designs that were evolved in the electrotechnics department of the University of Manchester. The computer is a good example of a joint enterprise. It was built by Ferranti Ltd., on behalf of the Ministry of Supply, and it is installed in its spiritual home, Manchester University, in a building provided by the Royal Society, where it will be available for numerical research work of all kinds, by the mathematics, science and engineering departments of the University.

Although the new computer is fundamentally akin to a number of other machines which have been built or are being built in this country, as well as on the Continent and in the U.S.A., it embodies several new ideas, to which reference will be made later in this article. In common with all other automatic digital computers, the Ferranti machine can perform three main functions. First, it can carry out arithmetical calculations with extreme rapidity; for example, it takes only two seconds to do 600 multiplications of pairs of ten-digit decimal numbers, which would require a normal day's work by a girl with a standard desk calculating machine. Secondly, it has a capacious "memory." It can "remember" a great many numbers, together with the long and elaborate series of instructions which have to be obeyed in order to perform a complex calculation automatically. The new machine, in fact, is believed to have a bigger memory storage than any other in existence; it can store 16,000 twelve-digit numbers and recall any one of them within $^1/_{30}$ second. Thirdly, the machine can make decisions: that is to say, it can decide, at any required stage in the calculations, which of two or more contingencies has occurred, and it can determine its future course of operations accordingly. The two or more alternative courses of action must, of course, have been prescribed by the mathematician who is operating the machine. Nevertheless, the machine has the power of discriminating between the alternatives, in the light of the results it has achieved up to that point.

Two other characteristics of the Ferranti computer are common to other automatic computing machines—the ability, automatically, to accept information and to record results. In other words, the computer has an input and output mechanism which allows the operator to feed numbers into the machine and to extract from it the results of its calculations.

It is worth recalling, in passing, that Charles Babbage anticipated by more than 100 years these principles, which are incorporated in modern automatic coumputers. Babbage, who was Lucasian Professor of Mathematics at the University of Cambridge, clearly foresaw the feasibility of making calculating machines and the possibilities that their use would give rise to in the field of crystallography, for example. Unfortunately, Babbage's ideas came a hundred years too soon: the two machines that he started to build—the Difference Engine and the Analytical Engine were not completed, first, because he could not get the necessary financial backing and, secondly, because he lacked the facilities provided by electronic devices upon which modern electronic computers depend. An interesting sidelight on the second limitation is contained in Babbage's estimate that the speed of his machine would be sixty additions per minute, or one multiplication of two fifty-digit numbers per minute. The Ferranti machine is estimated to operate a thousand times as fast; it will add together two twelve-digit decimal numbers in a total time of 1·2 milliseconds and it will multiply two numbers of the same magnitude in 3 milliseconds.

Yet another comparison is instructive. Babbage planned to use punched cards to provide the requisite coded information for the input end of his machine and for extracting the results produced at the output end. He also proposed to use punched cards as an auxiliary store in the "memory" section of his machine. In the computer that we saw demonstrated last week modern techniques have allowed Babbage's methods to be taken a stage further: punched teleprinter tape is used for the input of information, while the results are automatically printed on a standard teletype machine. Subsequent versions of the Ferranti computer will, however, probably be adapted to use punched cards as well.

A detailed description of the new computer is clearly outside the scope of this article, but a general idea of the anatomy of the equipment and its operation is given in the following simplified account, which is based on information compiled by Dr. B. V. Bowden, of Ferranti Ltd., who has been intimately concerned with the engineering of the project.

Anatomy of the Computer

All the calculations made in the computer are done with numbers expressed in the binary system, which uses only two digits "0" and "1," since it is convenient, in electrical circuits, to represent information by using devices which have only two "states."

For example, a relay can be open or closed; a spot on a cathode ray tube can be present or absent; valves which are turned hard "on" or hard "off" are easily controlled; a pulse may be present or absent in a particular interval of time; in the familiar teleprinter tape, a hole may or may not be punched in a particular place. By contrast it is much more difficult to arrange, for example, that a valve is turned exactly one, two or three tenths "on." The conventional decimal system was devised to suit a system of counting based on the number of "digits" on the two hands, but when making a computing machine it is far more convenient to use a "binary" system, which is better suited to the anatomy of the machine.

The binary system employs only two symbols, namely, 0 and 1. The number 2 in decimal notation is 10 in binary notation and, to take a more complicated example, 10001001 in binary form means 1×2^7 plus 1×2^3 plus 1×2^0, which in decimal form is 128 plus 8 plus 1 or 137, that is, 1×10^2 plus 3×10^1 plus 7×10^0. It requires about $3n$ binary digits to represent a decimal number of n digits, but nevertheless there is a great simplification in the machine if we make use of the binary system. The machine automatically converts numbers which are supplied to it as decimals into binary form before it starts work on them, and after the computation is complete it reconverts to decimals before printing the result. The speed of the machine is such that, for example, it will convert an eight-digit decimal number into binary form in less than a tenth of a second. The converse process takes about the same

time, so that the time required for the conversion is usually negligible.

Information of all kinds, including both numbers and the instructions which the machine has to obey, is handled in the form of chains of pulses. Since the significant fact is to be the presence or absence of a pulse in a particular interval of time, it is necessary to provide a time scale or "clock." A 100kc/s quartz crystal oscillator runs continuously, and provides the standard time for the whole machine. All the waveforms which are used in the machine are derived from this crystal. First, the oscillator provides a series of "pips," ten microseconds apart. These pips are fed into twenty-four pairs of valves, connected in a chain. The circuit acts like a high-speed rotary switch, connecting twenty-four wires in succession to a source of potential. There are, therefore, twenty-four wires from each of which can be taken a pulse every $24 \times 10 (= 240)$ microseconds. These pulses are called the *P* pulses, and they are taken all over the machine. The numerical significance of each one of a train of pulses representing a number is determined by the particular *P* pulse, during which it occurs. All the pulses in a train are of fixed amplitude and duration, and they occur at a time fixed by the 10 microsecond pips coming from the quartz oscillator. They can only be present or absent; if they are present, their size duration, and timing are all fixed by the machine.

The path which the pulses take through the machine is determined by a series of

THE FERRANTI DIGITAL COMPUTER, MARK 1

electronic "gates," which behave much like very high-speed relays of the normal type. The "instructions" given to the machine control the gates, and the numbers pass through them in such a way that the successive operations which are performed on them are those which are required by the programme set up by the operator. There is a fairly close analogy with an ordinary telephone exchange. By dialling a number a subscriber sends successive series of pulses to the exchange. These act as "instructions," open or close several hundred relays, and open a path for the subscriber through the exchange. He can then transmit more information through this path; if he were to use a teletype machine, the information which he transmitted would be of the same form as the pulses which controlled the operations of the exchange itself. A telephone exchange is complicated not because of the complexity of the components of which it is built, but because of the complexity and multiplicity of its interconnections. The computer is complicated in much the same way, and for much the same reason. Without attempting to describe it in detail, we shall explain its operation in broad outline and give a simple account of the novel circuit elements which are used in it.

Memory Circuits

So far we have considered chains of pulses passing repeatedly round the machine. It is necessary to have some way of storing them and, moreover, of doing so without using very large numbers of valves. The first high-speed electronic computing machine, which is called the ENIAC, was built during the war for the American Army. This machine used a memory which, in our nomenclature, consisted entirely of "staticisors." These components will be described later on; here it suffices to say that a staticisor needs one valve pair to store a single binary digit. The ENIAC used about 20,000 valves in all, and even so its memory is smaller than is really desirable. Two or three less extravagant systems of storage have been proposed, and before we describe the system which has been made for the Ferranti machine it may help if we consider another kind, which is now being used in several other machines, namely, the mercury delay line.

This device consists, essentially, of a steel tube filled with mercury and having a quartz crystal mounted at each end. If electric pulses are applied to one crystal, waves travel through the mercury at a speed of about a mile per second. When they arrive at the far end of the tube they strike the other crystal, and produce small voltages across it. If a chain of pulses is sent down a tube 5ft long they will emerge from the other crystal about a millisecond later. They can be amplified by valves and fed back into the tube so that they circulate continuously. In practice, if this is done, the pulses become distorted as a result of successive journeys through the tube; on the other hand, it is possible to use each emerging pulse to open a gate. A new and undistorted pulse derived by a circuit controlled by the quartz crystal will pass through the gate and can be applied to the input crystal in the mercury tube. The chain of pulses will now circulate indefinitely as long as the set is kept "on." In an existing machine (the EDSAC, in Cambridge), the pulses last about a microsecond and are a microsecond apart, so that approximately 500 pulses are stored in one mercury tank. Whenever it is required to read a number it can be done by opening a gate at the appropriate moment, when the pulse chain in which one is interested will pass out into the machine. By using a dozen such tanks it is possible to increase the total storage capacity correspondingly. This machine has a memory which can be likened to a dozen files, any one of which can be instantaneously selected; but the contents of each file can be studied only by going through it page by page. A limitation of this type of memory is that it is usually necessary to wait for some time before the pulse chain which one wants is actually emerging from the mercury tank.

The High-Speed Electrostatic Store

This unit is the heart of the machine, and its properties have conditioned the lay-out and operation of the whole computer. This "memory" is due to Professor F. C. Williams and Dr. T. Kilburn, who described it in a paper* before the Institution of Electrical Engineers. In the interests of simplicity the present account omits all mention of the complicating secondary effects.

The storage system uses an ordinary cathode ray tube, which has a pick-up plate mounted outside it, immediately in front of the fluorescent screen. Suppose that we bombard a single spot on the screen, and that the voltage of the beam has been chosen so that the coefficient of secondary electron emission is about $1\frac{1}{2}$; this means that for every two electrons in the primary beam which strikes the target three electrons leave it. The spot which is being bombarded becomes positively charged, some of the electrons which are emitted fall on adjacent parts of the fluorescent screen, but the majority will be attracted to the conducting coating on the inside of the bulb, which is usually connected to the final anode of the electron gun. There is a small capacitance between the spot on the screen and the pick-up plate, so the result of bombarding an uncharged spot on the screen will be to produce a small positive pulse on the collector plate, and this can, of course, be amplified to any size required. If one bombards a spot which has recently been bombarded, the potential of the spot will already have attained its equilibrium potential, so that no positive signal pulse will be produced by the amplifier. One can therefore tell, by bombarding a spot on the tube, if it has recently been bombarded or not. But it will be clear from this argument that in the act of reading from the fluorescent screen one must write all over it, and erase everything which was written there. Moreover, the insulation of a screen is such that any charge distribution which has been built up on it will decay in a short time (perhaps a second or two).

A cathode ray tube used in this way is not much use as a memory. To improve it, suppose that immediately after bombarding one spot A we move the beam by a small distance, about equal to a spot diameter, and then bombard an adjacent spot B. Slow secondary electrons will be emitted by B and some of these will be attracted by the most positively charged spot in their neighbourhood, which is A. They will fall on A and after a short time they will remove the positive charge on A completely. This means that if the spot A is now bombarded for a second time a positive signal will appear in the amplifier. On the other hand, if the spot B had not been bombarded since the first bombardment of A, no positive signal would come from the amplifier during the second bombardment of A, because, of course, it would still be at its equilibrium potential, as explained in the previous paragraph.

Consider a mosaic of pairs of spots, A_1, B_1, A_2, B_2, &c. The individual spots in a pair are to be very close together, but adjacent pairs are far enough apart to ensure that secondary electrons emitted during the bombardment of one pair do not fall on any other pair in the screen. We bombard A_1 and then B_1, and so on. When we bombard A_1 we get a signal which tells us whether, during the last cycle of bombardment, B_1 was bombarded or not. If B_1 was so bombarded we get a positive signal when we bombard A_1, if B_1 was not so bombarded we get no positive signal when we bombard A_1. Now we get this signal a short time before we are due to bombard B_1 for the second time, and during this time we can make a signal derived from the bombardment of A_1 operate an electric circuit which determines whether or not B_1 is to be bombarded. We can, in fact, arrange to re-bombard it if it was bombarded last time, and to refrain from bombarding it if it was not bombarded last time. By doing this we renew the charge pattern on A_1, B_1 and, moreover, we can read off what we had stored there. If we repeat this process sufficiently often the charge which is lost by natural leakage from the screen will be replenished, and the charge pattern will remain unaltered for as long as may be required.

The great advantage of this type of "memory" is that, by suitably controlling the potentials on

* "A Storage System for Use with Binary Digital Computing Machines," *Journ.*, I.E.E., *96*, 81 (1949).

the deflector plates of the cathode ray tube it is possible almost instantaneously to direct the beam to any part of the screen in which we happen to be interested. Here, it seems, is a memory, the contents of which are immediately available to the machine on demand. There are two complications to be mentioned at this point. First, it is found better not to use the simple arrangement of pairs of dots which has been described. Instead the beam is defocused to cover an area about four times its normal size in order to read; this corresponds to A_1 and the beam is then sharply focused to write, corresponding to B_1. A_1 is therefore an annulus, surrounding B_1; the principle of operation of the store is substantially unaltered, and the output signal is at least three times as big as it is when the dot pair method is used. Finally, it must be remembered that the charge pattern will disappear from the screen unless it is renewed once or twice a second; the operation of the machine has to ensure the regeneration of all parts of the store, whether or not they happen to be needed at any particular moment in the calculation, as well as the reading out of the information which is being used in the computation.

The face of a single cathode ray tube is arranged to hold sixty-four lines, each of which contains twenty pairs of dots (or focus-defocus dots). Each pair of dots stores one binary digit, so a single tube contains 1280 binary digits in all. To store so large a number of spots on a single tube it has been necessary to develop a special cathode ray tube, with an unusually good "gun," which will produce a spot not much more than 0·1mm across at 1200V. It is necessary to make the screen exceedingly carefully in order to avoid small specks of impurity which will prevent the storage of a digit on a particular part of the screen.

The electron beam is made to trace out the lines, one at a time, by the potentials on the X plates of the c.r.t., and the choice of the particular line which is to be scanned is made by the potentials on the Y plates. To ensure the regular regeneration of the whole store, the tube face is scanned as follows. Consecutive 240 microsecond periods are devoted alternatively to regeneration of the store and to reading off the numbers which are needed in the computation. In other words, in alternate X sweeps, the whole face of the tube is scanned, regularly, line by line and, in the interleaved X sweeps, the machine refers to the particular line on the particular storage tube, from among the eight in use, on which is stored the information needed. Thus half the time is devoted to regeneration of stores and half to computation. The time for which one may have to wait before obtaining access to information which one needs is one X sweep-time, or 240 microseconds. The high speed of the machine is primarily due to the fact that this time is so short.

The Main Magnetic Store

So far we have considered the memory which contains information required to be immediately available. On the analogy of a human computer, this memory corresponds to the book of tables which he has on his desk, and to the paper on which he records the intermediate results of his computations. In addition, the computer needs to have occasional reference to a main library, which contains, for example, tables of functions which he needs but seldom, and instructions which enable him to perform certain standard types of computations. The main store of the machine contains about 650,000 binary digits. This total is only about the equivalent of the contents of a forty-page book of tables, but one can use the information so economically that it is adequate for almost all the operations which can reasonably be foreseen.

The main memory stores digits by using principles which have been used in recording sound on magnetic wires and tapes. The digits are stored, not on wire, but on the surface of a drum. The drum is about 6in in diameter and 8in high, and is coated with about a thousandth of an inch of nickel. A series of 256 writing and reading heads is mounted one above the other along a series of generating lines of the drum; the nickel surface is about a thousandth of an inch away from the heads and moves at a speed of about 30 m.p.h. This high speed makes it possible to record at the normal digit frequency of 100kc/s. To "write" on the drum, one first of all chooses a particular head (the choice is made automatically, by means of relays) and then, at a time which is determined by the master oscillator, a current is passed through the head, first one way and then the other. The digits 0 and 1 are written by reversing the order in which the currents are sent through the head. Digits therefore exist in the drum in the form of little magnets. The magnetic system once set up will last indefinitely.

As the magnets pass beneath the reading heads they induce very small voltages in the heads. The voltages can be amplified, and, by observing which direction of magnetisation came first in a digit period, one can read either 0 or 1. This system of observing a waveform at a particular instant of time, which is controlled by some other waveform derived, for example, from the clock, is known as "strobing" the original waveform. It is a process which has become familiar through its use in radar circuits of all kinds, and it is frequently used in this machine.

It will be clear from the account which has been given of the operation of the magnetic memory that it is necessary to keep the drum in synchronism with the operation of the main machine, so that a signal which has been written will emerge during the corresponding clock pulse pattern when it comes to be read. The speed of the drum is, in fact, controlled by a servo system, which keeps it accurately in the proper phase relation with the P pulses mentioned above. The maximum error in the position of the drum at any specified time is less than a thirty-thousandth of its circumference. The development of the drum called for considerable precision engineering; for example, the maximum eccentricity is nowhere greater than three ten-thousandths of an inch.

Each reading head has a separate head amplifier, which is driven via a step-up transformer. The choice of the track from which one is reading is made by switching on the appropriate head amplifier, which can be done almost instantaneously, so one can read from the drum in a time which is of the order of one revolution (about 30 milliseconds). On the other hand, there is only one writing amplifier, and it is switched to all the heads when it is required by means of a "tree" of relays. One has, therefore, to wait a little longer before one can write on the drum. Because the access time for the drum is so much longer than that for the high-speed memory (30 milliseconds, as compared with 200 microseconds) it is arranged to transfer information in large quantities at fairly infrequent intervals. It is normal to transfer the contents of one or two cathode ray tubes at once.

The magnetic store contains 256 tracks, each one of which can hold 2560 binary digits (64, 40-binary digit numbers or 128, 20-digit binary numbers). A half track is equivalent to one cathode ray tube store, which contains 1280 digits i.e., 32, 40-digit numbers or 64, 20-digit numbers.

The main store will consist of eight high-speed cathode ray tubes, and the time taken to call down one half track into the main store is 30 milliseconds. The digit period is 10 microseconds. A "beat" or "X" time base is 200 microseconds, which with the addition of 40 microseconds fly back time gives a "beat" time of 240 microseconds. A complete arithmetic operation usually occupies four or five times this period, i.e., 0·96, or 1·2 milliseconds.

Our illustration shows a general view of the Ferranti Digital Computer, Mark I, installed in the University of Manchester. In the centre is the control console with its monitor tube panel, tape punch and tape reader. The cabinets on each side of the console accommodate all the apparatus of the computer proper.

(To be continued)

Some Early Timepiece Escapements

AN interesting exhibition showing the history of time measurement, which was recently opened in the Guildhall Museum, has been arranged by the Clockmakers Company of London as its contribution to the Corporation of London's celebrations in connection with the Festival of Britain. The exhibits are particularly designed to show the important part played by the British clock and watchmaker in the development of accurate time measurement and it forms an interesting background to the very fine collection of timepieces in the museum.

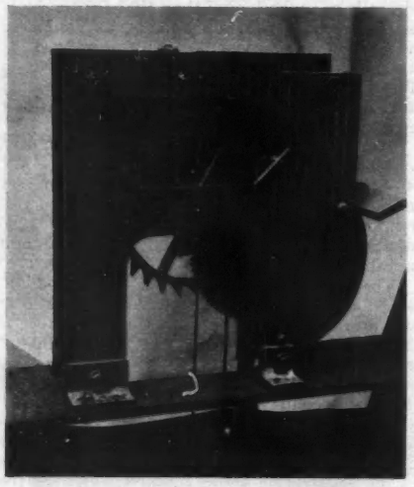
There are but few engineers who have not at some time examined an old timepiece and been impressed by the ingenuity and inventiveness of the clock and watchmaker of bygone days and there is no doubt that these old craftsmen were the forerunners of the precision engineering industry as we know it to-day. When looking at the many models and other exhibits at the Guildhall Museum and noting the high standard of craftsmanship called for in making the very small, complicated mechanisms it is difficult to understand how such work could be accomplished with the relatively crude tools and restricted range of materials available when the movements were conceived.

The accurate working of a timepiece depends largely upon its escapement and several of the models included deal with some of the interesting work carried out on this part of timepiece movement. Many escapements have been invented and made but only a few attained that standard of accuracy which is essential in a timepiece. The models showing some of these notable and more successful escapements in the exhibition have been made by apprentices of the Letchworth works of the British Tabulating Machine Company, Ltd., and are excellent examples of modern precision craftsmanship. When a spring-loaded plunger at the side of a model is pulled a small weight suspended at the rear is raised and this weight, when the plunger is released, sets the escapement in motion. The escapement then runs for a short period at a speed which allows the function of each part to be clearly followed. The various parts, as can be seen from our illustrations, are indicated by means of engraved tabs and pointers.

The first of the models is of the verge escapement with a foliot which is the earliest escapement known and has been traced back to 1364, although it was probably developed rather more than fifty years before. It was first used with a foliot as shown in the model, but was later adapted to pendulum control. In this mechanism the verge has two pallets, which are set at different angles to engage the upper and lower teeth cut in the side of the escape wheel. Integral with the verge is the foliot at the upper end and adjustably mounted at each end of the foliot is a weight. With this arrangement the escape wheel can turn only by oscillating the verge to and fro. In the sequence of operations, as the pallet at the top of the verge escapes a tooth, the lower pallet is contacted by a tooth on the opposite side of the wheel. By virtue of the inertia of the foliot the verge continues to swing and, through the lower pallet, pushes the escape wheel backwards. At this point the wheel and the verge are stationary for a brief period until the driving pressure on the escape wheel comes into effect, giving an impulse to the verge in the return direction through the lower pallet.

As the tooth escapes the pallet the upper pallet contacts a succeeding tooth as the verge swings and another cycle begins.

It will be appreciated that the inertia of the foliot with its weight limits the rate at which the verge can be oscillated and this rate can be varied by moving the weight on the foliot or the power applied to the escape wheel. In this escapement the defect of the foliot is that its time of swing varies with the force applied to the escape wheel and although its "unlocking" or tooth-releasing arc is set, the rest of the swing varies with the applied power, the frictional efficiency, &c. In other



ANCHOR OR RECOIL ESCAPEMENT

words, the foliot did not swing isochronously, as it should do for good time-keeping purposes. When the pendulum was applied to a clock in 1658 verge escapements were adapted to suit it.

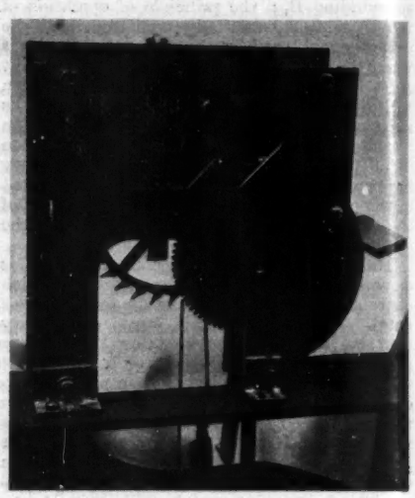
What is said to have been the first escapement invented, after the verge, was the anchor or recoil escapement which has been attributed, though without any evidence, to the famous Dr. Hooke, about 1656 and adapted for the turret clock in King's College, Cambridge, by William Clement in 1671. Unlike the verge escapement (with which only a short pendulum could be used for the large swing required for the foliot) it worked with a small swing and made possible the use of the long seconds pendulum of the grandfather clock.

In the mechanism the anchor is not fixed directly to the pendulum but in a crutch linked to the pendulum rod. As the pendulum swings it actuates the crutch and brings in turn the pallets at each end of the anchor into contact with the teeth of the escape wheel. As a tooth on the wheel escapes from a pallet a tooth further round drops on to the flat surface of the pallet at the other end of the anchor. The swing of the anchor continues until the end of this movement approaches when the pallet is near the top of the tooth. From that stage on until the tooth escapes, it gives impulse to the anchor. When this tooth escapes another tooth drops into the pallet at the opposite end of the anchor and with continuation of the swing that tooth rides up its pallet. On the return swing impulse is given to the anchor through the second pallet. The faces of the pallets on the anchor are so shaped that, as the teeth ride up them, the anchor forces the escape wheel backwards, giving a recoil, which tends to keep the arc of the pendulum constant with a varying driving force. A very important factor in the design of this escapement is that any variation in the motive force, which would affect the impulse and tend to alter the vibration of the pendulum, is accompanied by an equivalent variation in the resistance offered at the escape wheel teeth, combined with a proportionate change in the angle of the pallet faces. As a result, with fairly wide changes in the driving force, the arc of the pendulum remains nearly constant.

Another model shows the "dead-beat" escapement invented by George Graham about the end of the seventeenth century and, as can be seen from the photograph, is somewhat similar to the anchor escapement. In it the pallets have two faces, the "locking" faces formed on the outer surfaces of the pallets at the ends of the anchor and the "impulse" faces on the lowermost ends of the pallets. The teeth of the escape wheel fall first on the locking faces. Then, as the pendulum swings, the teeth pass to the impulse faces, where they deliver an impulse to the pendulum before disengaging from the pallet. This escapement is still used in many clocks.

The verge escapement was the only one used in watches until George Graham invented the cylinder escapement, about 1722. It is similar in some ways to the verge and is so designed that the recoil action is eliminated. In the model the balance is shown below the escape wheel instead of above it, as is usual in clocks and watches with the cylinder escapement—this has been done to show the working more clearly.

The cylinder escapement has a balance wheel with a hair spring and on its spindle is a hollow cylinder. Part of the cylinder wall is cut away to form two lips, designed to engage with the teeth of the escapement wheel. These teeth stand up round the rim of the wheel and are so formed that as the leading portion of a tooth contacts the front lip of the balance wheel cylinder it gives an impulse. As the tooth escapes from the lip it falls on to the inner surface of the cylinder close to the opposite lip. By the swing of the balance the cylinder continues to turn with the tooth rubbing against the inner surface until the balance reaches a stationary position. The back swing

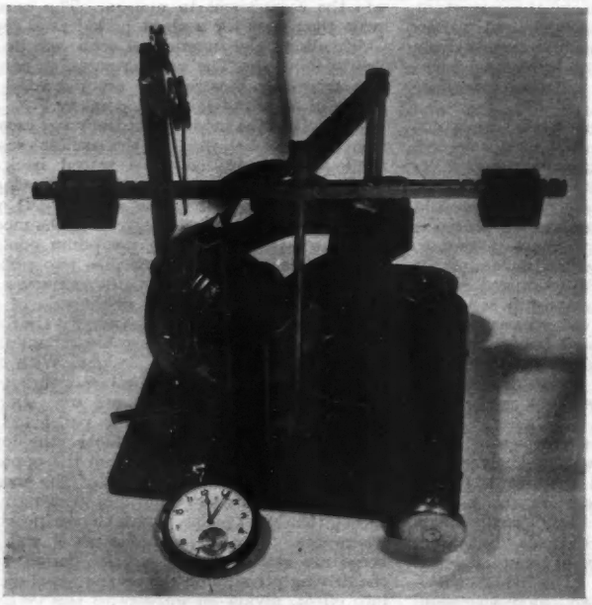


DEAD-BEAT ESCAPEMENT

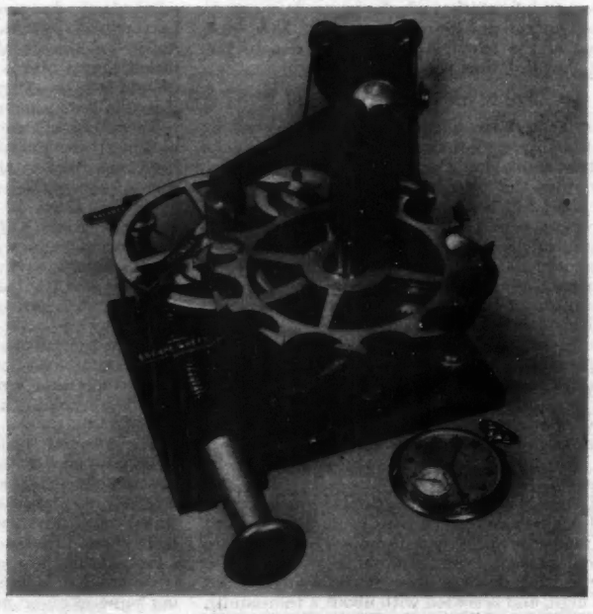
of the balance starts and, as the toothfalls off the lip, its sloping upper surface gives an impulse to the cylinder in the opposite direction. The following tooth of the escape wheel then contacts the outside wall of the cylinder and rubs against it until, in the wheels return swing, it drops over the leading lip on the next cycle of movements.

In this escapement the locking faces, which prevent continued motion of the escape wheel, are the outside and inside surfaces of the cylinder and the impulse faces are the lips formed on the edges of the cut-away section. In the verge and anchor escapements described above, the same face was used for both locking and impulse.

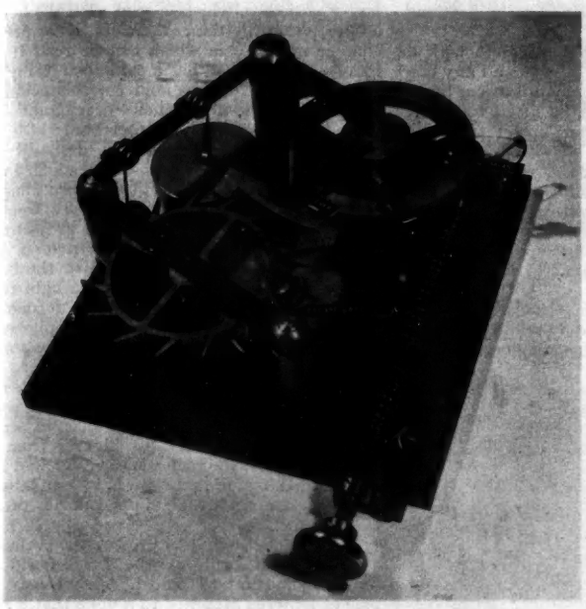
The cylinder escapement had an advantage, in addition to its "dead-beat" action, in that



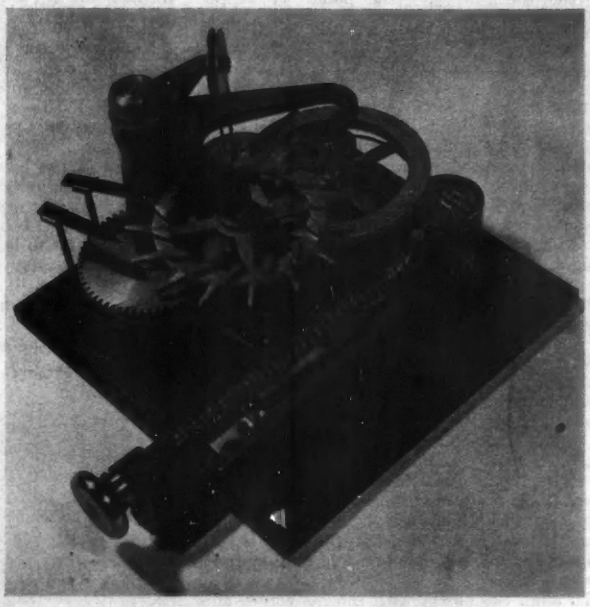
VERGE ESCAPEMENT WITH FOLIOT



CYLINDER ESCAPEMENT



LEVER ESCAPEMENT



DUPLEX ESCAPEMENT

it gave a much freer arc to the balance and it also permitted watches to be made thinner than hitherto. A particular disadvantage was that the cylinder itself was very frail and easily broken, owing to the cutting away of much of the wall.

The lever escapement, which is used in all modern watches, was invented by Thomas Mudge in 1759, and was the first "detached" or "free" escapement to be used. The term detached is applied because the balance wheel is quite free of the watch train for a considerable portion of its swing.

In the mechanism, the model of which is illustrated above, a roller mounted on the balance arbor carries a pin, which provides the connection to the escape wheel through the fork at one end of the pivoted lever. The anchor on the lever engages the escape wheel through locking faces on the sides of the pallets formed at each end and the impulse faces formed on the lowermost edges of the pallets. As the balance wheel swings the pin engages the lever to rock the anchor. When the locking face of the pallet at one end of the anchor releases a tooth, the tooth comes into contact with the impulse face, which continues the turning movement started by the pin and brings one side of the fork into contact with the pin. This gives impulse to the balance until movement of the lever is halted by a stop, when the pin is free to move out of the fork. At this stage a tooth of the escape wheel is locked on the opposite pallet of the anchor and the lever and escape wheel remain at rest free of the balance. When the balance has completed its swing and begins its return movement its pin re-enters the fork and the cycle of movement re-starts in the opposite direction. A safety finger is fixed on the lever below the fork to prevent the lever turning except when the pin is in the fork. The finger registers in a notch cut in the roller, which gives passage to it when the pin is in the fork, any attempt the lever might otherwise make would be prevented by the finger butting against the profile of the roller. The pointed teeth used on the escape wheel, shown in the model, have been replaced by "club-foot" teeth in modern movements.

High-class English watchmakers in the latter half of the eighteenth century used the "duplex" escapement shown by another of the models. This escapement, it is thought, was possibly invented by Dutertre of Paris. It is of an ingenious design but was somewhat fragile and difficult to make, as will be appreciated when examining the photograph we reproduce. A particular advantage it had over the cylinder escapement is that the locking is on a cylinder of very small diameter, whilst the impulse is given by a relatively long arm.

The balance arbor in the escapement has a small notched roller just above the wheel and above the roller is a long arm. The escapement wheel has two sets of teeth, one round its periphery and the other formed on its upper surface. When the balance is turned one of the peripheral teeth enters the notch in the roller and as it escapes past the roller gives a small impulse to the balance. Whilst the tooth is in the notch one of the teeth on the top of the escapement wheel engages the long arm of the balance and gives it the impulse. On the return swing of the balance the notch slips past the tooth locked on the roller without allowing it to escape. With this arrangement only one impulse is given for each double swing of the balance—thus the name duplex.

There is also to be seen in this exhibition the No. 5 chronometer watch made by John Harrison and his son in 1759, which was a duplicate of the No. 4 watch with which he won the prize offered in 1714 to anyone who devised a means of finding longitude at sea by timing a voyage to the West Indies. The free pendulum clock of Mr. W. H. Shortt, which is now used in many observatories, and is stated to maintain correct time to a thousandth of a second a day, displayed in the exhibition, shows the culmination of the work of the watch and clockmaker over the years of timepiece development.

The British Instrument Industries Exhibition

No. II—*(Continued from page 14, July 6th)*

Hilger and Watts, Ltd.

Useful applications of optical instruments in engineering gauging and inspection are to be seen among the exhibits displayed by Hilger and Watts, Ltd., 98, St. Pancras Way, Camden Road, London, W.1. In particular, optical projectors for gauging are represented by the "T500" projector, by the newer "T600" equipment, and by a smaller instrument known as the lathe projector, which is suitable for inspection control of small parts.

The "T500" projector (illustrated in Fig. 11) embodies a work table, which supports the part that is being examined, and an optical system whereby a magnified image of the part is thrown on a circular ground glass screen, 21in in diameter. The work table is designed to accommodate objects weighing up to 50 lb and measuring up to 8in diameter by 14in in length. It is provided with micrometers reading to 0·0001in (or 0·0025mm), permitting accurate measurements to be made in conjunction with slip gauges over a length of 7in and over a height of 2½in. The focusing movement on the work table has a total travel of 4in. The protractor reads by a built-in projection system to one minute of arc.

The light source, which gives sufficient screen brightness to allow the use of the projector in a normally lighted room without shielding, is a 250W high-intensity mercury vapour lamp. It is housed in a well-ventilated lantern, with a condenser lens system for parallel light illumination of the object under test. The condenser provided with the instrument is suitable for use at all magnifications between ×10 and ×50, and it can readily be interchanged with special condensers for projection lenses of magnifications ×5 and ×100 respectively. A detachable green filter is fitted to the lamp house, to give an image of a pleasant colour for observation while ensuring the maximum sharpness of the image. Since the mercury vapour lamp has its most powerful emission in the range of transmission of the filter, the use of the filter does not reduce the brightness of the image to the same extent as when a filament lamp is used. A screw adjustment operated by an external knob provides lateral movement of the lamp for collimation, and a screw-operated height adjustment is also provided. The whole lamp house is mounted in ball bearings and can be rotated over a total angle of 10 deg. to provide oblique illumination at the correct helix angle of a screw thread; a conveniently placed angle scale indicates the position of the lamp house.

Both vertical and horizontal measuring movements are provided on the measuring work stage. The stage itself is provided with wide

horizontal and vertical faces to which the devices for holding the work can be attached by means of "T" slots, which run the whole length of the stage on both faces. A focusing movement of some 4in enables even awkwardly shaped objects to be brought into the object planes without difficulty.

The horizontal measuring movement is fitted with a micrometer reading to 0·0001in with a range of direct measurement of 1in that can be extended to 7in by interposing slip gauges. The micrometers are of special design with non-rotating anvils, preventing wear on the slip gauges. Spring tension keeps the micrometer in contact with the anvil of the measuring carriage, but can instantly be released so that the carriage can be traversed quickly by hand for aligning the object.

Vertical movement is controlled by a screw and cam device which operates smoothly, even with the maximum load of 50 lb. The vertical position is measured by a micrometer reading to 0·0001in over a distance of 1in, which is extended to the full range of movement of 2½in by slip gauges. As with the horizontal movement, the micrometer is non-rotating and the slip gauges are thus saved from wear. A conveniently situated dial gauge provides a zero indicator for the micrometer and ensures accurate setting.

To align the object with the horizontal and vertical directions of movement the whole top of the work stage can be tilted about the optic axis, by a screw motion, up to a maximum of ±2½ deg.

The work stage can be rotated about a vertical axis, by hand, up to 30 deg. on either side of the axis so that objects whose dimensions in thickness are not perpendicular to their faces (angle-faced cutters, &c.) can be suitably oriented to the optical axis. An index shows the angular position of the stage on the same scale as is used for the lamp house setting. Ball bearings ensure ease of adjustment in spite of the heaviness of the stage.

Focusing is performed by a screw-controlled movement of the work stage and lamp house assembly, the projection lenses being fixed in position to ensure maintenance of their specified magnifications. The movement is kept strictly rectilinear by ball bearings running on optically worked faces of high accuracy, and measure-

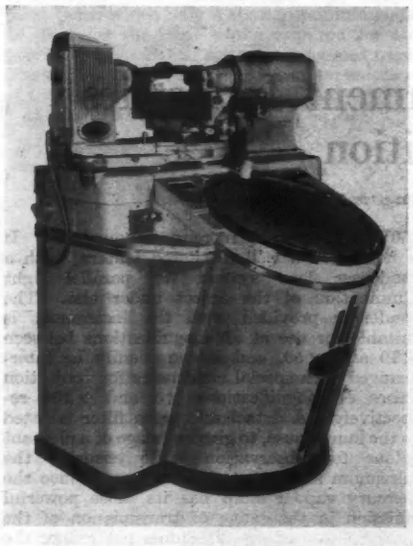


FIG. 11—"T500" PROJECTOR—HILGER & WATTS

ments can be taken between portions of an object which are not in one plane.

The projection lenses are mounted on a robust rigid mounting on the right-hand side of the projector and can be quickly interchanged without risk of alteration in magnification.

A new range of projection lenses for the "T500" projector has been specially computed in the applied optics section of the Hilger research and development department, to give full value to the capabilities of this new projector. They are very carefully matched so that they give exactly their specified magnifications within ±0·005in over 20in length.

Each projector is supplied complete with a lens giving a magnification of ×25 and any one or more of eight lenses, with magnifications ranging from ×5 to ×100 can be fitted to order. The projection distance from object to image is 120in.

Three of the lenses (×25, ×50 and ×100) have been specially computed to include screw thread form projection, where the light is inclined at the helix angle of the thread and will operate with light inclined up to the angles stated above with minimum loss of definition and distortion.

The projection screen is circular, with an overall diameter of 21in and a useable diameter of 20in, the extreme annulus being occupied by

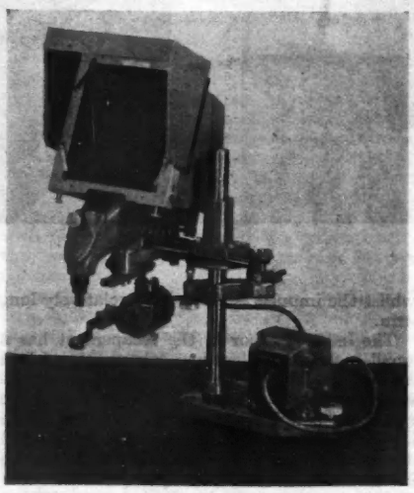


FIG. 12—LATHE PROJECTOR—HILGER & WATTS

a protractor scale, which is read by a projection device described below. The screen is finely greyed to give the best luminosity and definition of the image projected through it and has broken lines marked permanently upon it along two diameters at right angles to one another, forming reference lines for point-to-point measurements by the stage micrometers and for angular protractor measurements. When drawn or photographed templates are to be used this grey screen can be removed and a clear glass screen substituted for it.

The screen is fitted into a large metal ring mount which rotates freely and accurately about the centre of the screen. For fine setting a specially designed slow motion can be used. This mechanism takes the form of a disc with a ring of surface depressions into which the fingers fit comfortably as it is depressed to engage the slow motion. It is a convenient adjustment to operate and allows of very accurate setting. The protractor ring can be clamped by a screw device near the top.

Just above the slow-motion disc is a rectangular lens mounted over a recessed translucent screen with a scale marked upon it, on which an image of the peripheral degree scale of the protractor is projected. It is so arranged that the fixed scale spans the separation of two successive degree marks and, as it is divided into sixty divisions, the position of a degree mark upon it indicates the angle directly in degree and minutes—a much more convenient means of measurement than the conventional type of circle and vernier. The scale of minutes is itself 3in in length, so that the individual divisions are clearly spaced. A zero setting device is provided for the scale.

All the controls which the operator has to operate are grouped within easy reach, whether he stands or sits at the instrument. The work stage itself is at a height of 53in from the floor. The electrical equipment is built into the projector body and is readily accessible.

The newer "T600" instrument is essentially a smaller version of the "T500," and it incorporates some modifications. For example, in place of the transparent protractor scale of the larger projector, which is read with the help of a projection system, there is a somewhat simpler metal scale which can be read to one minute of angle and has a combined clamp and slow motion. The lens holder accommodates a series of lenses giving a choice of magnifications from ×10 up to ×100 by interchange of lenses.

The Hilger lathe projector is designed as a means of assisting production on small lathes by projecting on a ground glass screen a magnified image of the profile of the workpiece and the cutting edge of the tool. The projector, as illustrated in Fig. 12, is mounted on a base which can conveniently be fixed to the bench close to the lathe. It consists of a light metal body carrying the projection lens at one end and the screen at the other. A lamphouse on a mount throws light horizontally on to a small rectangular mirror (supported close to the workpiece), which reflects the beam across the work and into the objective, whence it passes via a mirror system to the projection screen. This screen is sloped back slightly from the vertical, so that the image is easily viewed from the normal standing position. Templates or drawings can readily be clipped in position on the screen.

Where it is desired to project the surface of the work rather than the profile, suitable illuminators can be supplied. They consist of a pair of lanterns attached to a yoke that is fixed on a locating face provided on the projector. Each lantern contains a high-intensity low-voltage lamp, which is run from a transformer mounted on the projector stand. With this system intense illumination is thrown on a small area of the work and the image of the surface is clearly visible.

Two forms of stand are available. One is arranged to allow the projector, after setting up, to be moved aside for chucking the work or tool adjustment, and to be returned, locating against stops; coarse and fine focusing adjustments are provided. The alternative form of stand is simpler, being designed to provide rigid and permanent alignment of the projector, with no more than the essential adjustments for alignment and focusing.

ELLIOTT BROTHERS (LONDON), LTD.

A firm with exhibits typifying current trends in supervisory control equipment for industrial processes is Elliott Brothers (London),

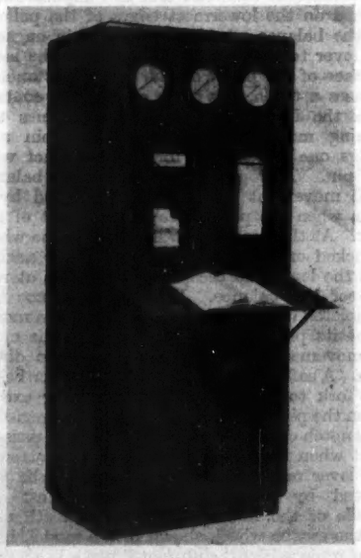


FIG. 13—STANDARD UNIT BOILER PANEL—ELLIOTT

Ltd., Century Works, Lewisham, S.E.13, a company which traces its origins back to 1800, when William Elliott opened a small workshop off Clerkenwell.

Prominent among the items shown on this company's stand is a supervisory control console which, as illustrated in Fig. 14, is so arranged that the operation of a large industrial plant can be supervised by a single operator. The par-

ticular console exhibited was built specially for the Anglo-Iranian Oil Company, Ltd. All the primary information required by the operator is displayed on a flow diagram, which forms the front panel of the desk, and facilities are provided for manual adjustment of plant conditions. Secondary information, such as temperatures at non-controlled points is available on demand, and chart records of selected variables are maintained by multi-point recorders. Control constants which are established initially, and thereafter need occasional adjustment only, are set up on controllers which are built into the cabinet and are accessible from the rear. The console is manufactured ready for assembly as a self-contained unit on site, the sub-assemblies being made interchangeable, wherever possible, to facilitate maintenance.

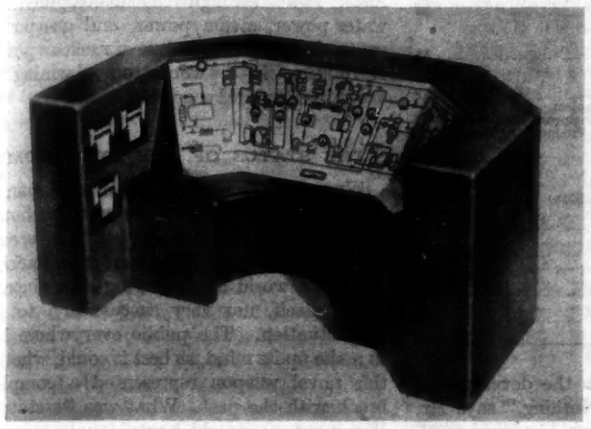


FIG. 14—SUPERVISORY CONTROL CONSOLE—ELLIOTT

The boiler panel illustrated in Fig. 13 shows a typical standard panel designed for the instrumentation of small boilers, all the necessary meters and recorders being arranged in a compact group. At the top of the panel are three draught gauges; below them, on the right, is a recording steam flow-meter, and on the left, a combined CO_2 and temperature recorder. Below the instruments is a hinged table, which can be used by the fireman in keeping his records, and which can be lowered to enclose a cupboard for the record books and chart rolls.

Among the instruments shown by the same company is a ten-channel strain display equipment illustrated in Fig. 16. The apparatus is a portable self-contained unit capable of displaying, on a single cathode ray tube, the strain at ten different points in a test piece. There are two alternative displays. The first consists of ten vertical traces, side-by-side and disposed above or below a zero line, the length of each trace indicating the amplitude of the corresponding vibrating strain, and the displacement of each trace from zero indicating the mean tensile or compressive strain. The second display consists of ten horizontal traces showing the wave forms of each strain. Vibration frequencies up to 3 kc/s can be displayed on all ten channels or, by a rearrangement, 0 to 8 kc/s can be accommodated on three channels or 0 to 11 kc/s on two channels. At maximum sensitivity 1mm deflection represents 0·001 per cent strain. The accuracy of indication is specified as ± 5 per cent on a 10cm deflection with 0·1 per cent strain.

The instrument incorporates ten independent strain gauge bridges which are excited by ten synchronised pulse generators. These generators are interconnected so that the pulses follow one another in sequence: there is a pause of one pulse interval after the tenth pulse and the cycle of operations is then repeated. At any instant only one bridge is receiving a signal.

ELECTROFLO METERS COMPANY, LTD.

Typical instruments used in the control of base load power plants, steel works, gasworks and industrial power installations generally are among the exhibits shown by Electroflo Meters Company, Ltd., Abbey Road, Park Royal, London, N.W.10.

The display includes a recent development in the company's range of pyrometric instruments—an electronic recording/controlling potentiometer. It is a continuously sensing and balancing instrument, both functions being carried out simultaneously. This sensing-balancing unit, in the standard potentiometric circuit, consists of an uncalibrated, pivoted, shockproof galvanometer movement used in conjunction with a single oscillator-amplifier valve.

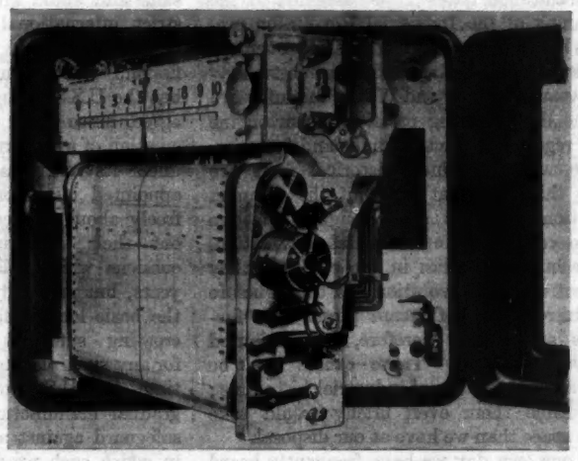


FIG. 15—ELECTRONIC RECORDING/CONTROLLING POTENTIOMETER—ELECTROFLO

The light short boom of the galvanometer movement carries a small aluminium wire loop. In parallel with it are two small fixed coils connected in the anode and grid circuits of the oscillator-amplifier valve. At the precise balance point the relative positions of the coils and the loop are so arranged that a prescribed amount of coupling exists between the grid and anode circuits of the valve. Any change in the position of the loop element caused by a deviation in the measured value causes the anode current to increase or decrease correspondingly. One of the relays therefore operates, energises the appropriate electromagnetic clutch and connects the continuously running driving motor in such a way as to restore the position of the slidewire contact, to maintain the original balance condition.

A general view of the instrument, with the mechanism swung partly away from the case, for inspection, is shown in Fig. 15.

The theoretical balance point accuracy of this system is stated to be one part in 3000 of the full-scale reading. Besides built-in safety devices to protect the electronic circuit and measuring circuit, the instrument incorporates automatic cold-junction correction and self-standardisation.

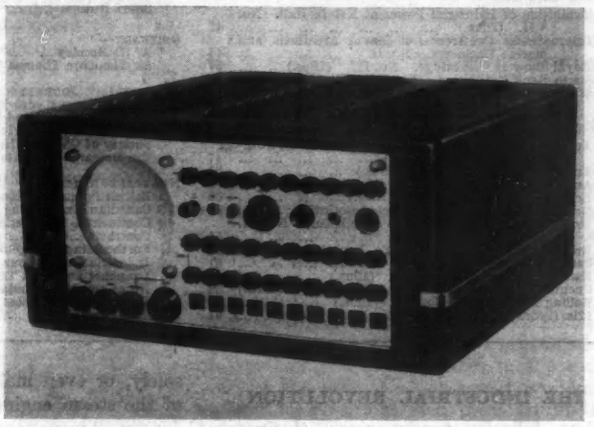


FIG. 16—TEN-CHANNEL STRAIN DISPLAY UNIT—ELLIOTT

All the normal modes of control are available with this potentiometer—two position, three position, modulating, proportional position, proportional speed floating control and proportional plus floating control. When this instrument is used in conjunction with the Electroflo hydraulically operated regulator it is possible to operate heavy valves and dampers, and complete control can be exercised over large industrial furnaces. The regulator can be tuned on site to suit the furnace under control, making optimum performance obtainable. The same kind of hydraulic regulator is available as a pressure controller and as a fuel/air ratio regulator. A high standard of furnace operation, in terms of furnace efficiency and fuel economy can therefore be obtained by a combination of the electronic potentiometer used for automatic temperature control and the hydraulic regulator adapted for controlling the furnace pressure and fuel/air ratio.

(To be continued)

"WELDED ROOF TRUSSES."—A brochure with the above title has recently been published by the Quasi-Arc Company, Ltd., of Bilston, Staffordshire, as the first of a series of publications on welded structures based on the demand for information experienced by the constructional design department of that firm over the past few years. The brochure gives information on the design of trusses and of joints. There are examples of truss lay-outs and the design of a 50ft welded truss is given in an appendix. The brochure may be obtained free of charge from the company, at the above address.

200kW BROADCAST TRANSMITTER FOR OSLO.—An order has been placed by the Norwegian broadcasting authorities with Marconi's Wireless Telegraph Company, Ltd., for a 200kW long-wave installation in Oslo, and comprises two 100kW air-cooled transmitters in parallel. Paralleling equipment, phase and coupling circuits will also be engineered by Marconi's for the Norwegian order. Air cooling dispenses with the large reservoir associated with water-cooled valves and the design of these new transmitters allows considerable saving in space, building and maintenance costs. The exhausted air, after it has been heated in its passage through the transmitter and assimilated the heat from the valves, is used to warm the transmitter building.

THE ENGINEER

Vol. CXCII JULY 13, 1951 No. 4981

Contents

PAGE

LEADING ARTICLES—
Industrial Revolution ... 54
Status of the Atom Bomb ... 54

SPECIAL ARTICLES—
Exhibition of Industrial Power at Kelvin Hall. No. VII. (Illus.) ... 42
International Conference of Naval Architects and Marine Engineers. No. II ... 45
Royal Show at Cambridge. No. III. (Illus.) ... 57
South Bank Exhibition. No. XI. (Illus.) ... 38
Western Region Gas Turbine Locomotive in Service. (Illus.) ... 40

Automatic Digital Computer at Manchester University. No. I. (Illus.) ... 47
Automatic Loop Diascope. (Illus.) ... 61
Automobile Proving Ground. (Illus.) ... 64
Brick Research Laboratory. (Illus.) ... 60
British Coal Utilisation Research Association ... 67
British Instrument Industries Exhibition. No. II. (Illus.) ... 51
British Transport Commission's Report ... 56
Canadian Turbo-Jet Engine ... 61
Early Timepiece Escapements. (Illus.) ... 49
Pneumatic Comparator of High Sensitivity. (Illus.) 62
Rolling Mill Design. No. III. (Illus.) ... 65
12in Hydraulic Pipe Bending Machine. (Illus.) ... 61

PAGE

LETTERS TO THE EDITOR—
Selection of Industrial Radiographers ... 56
Present-Day Locomotive Working in Great Britain 56

LITERATURE ... 55
Books Received ... 56
Short Notices ... 56

OBITUARY—
A. H. Mundey ... 55
Sir Theodore Thomas ... 55

A SEVEN-DAY JOURNAL ... 37
Kariba Gorge Hydro-Electric Project
Naval Architects' and Marine Engineers' Conference, 1951
Report of the Valve Industries' Productivity Team
Society of Chemical Industry
Tin Research Institute

NEWS AND NOTES—
British Patent Specifications. (Illus.) ... 71
Canadian Engineering News ... 67
Continental Engineering News ... 68
Contracts ... 70
Forthcoming Engagements ... 72
Industrial and Labour Notes ... 69
Launches and Trial Trips ... 70
Notes and Memoranda ... 70
Personal and Business ... 70
Technical Reports ... 72

THE INDUSTRIAL REVOLUTION

FEW fallacies persist more obstinately in the English mind than that an Industrial Revolution was brought about by the invention of the rotative steam engines of Watt and Trevithick, and the enclosure of the common lands. Many historians and economists, of whom we may select E. Lipson and A. L. Rowse, as among the latest and most easily enjoyed by the general reader, have shown by the careful study of old records that the movement of the working people towards industrial centres had begun long years before the invention of the steam engine; that industrial capitalism was not an innovation of the late eighteenth and early nineteenth centuries, and that the employment of large numbers of people by a single employer, sometimes in their homes, sometimes in factories employing many workers, existed as far back as the sixteenth century. Of John Winchcombe, Newbury, a cloth worker, it is recorded that within one room he had 200 looms, whilst William Stumpe took over two Abbeys—Osney and Malmesbury—and filled them with looms. Such examples as these, out of many, show that capitalism and the factory system existed long before the steam engine was even thought of. Indeed, as Mr. Lipson remarks, Engel's famous statement that "the proletariat was called into existence by the introduction of machinery" is based on ignorance of historical facts.

The term "revolution" suggests to the mind something of a cataclysmal nature, something that springs suddenly on a people and that overthrows rapidly an established régime. The "industrial revolution" had no characteristics of that kind to distinguish it, whilst, on the other hand, now that social historians have revealed its origins, it is seen to possess all the features of natural, if accelerated, evolution. The forms of industrial organisation associated with it were not new at the time and the admittedly evil accompaniments of the very rapid growth of towns and factories were not attributable solely, or even mainly, to the development of the steam engine. "Nothing," says Mr. Lipson, "more remote from historical truth can well be imagined than the prevailing misconception that the inventions of the late eighteenth century involved a violent breach with the past and effected an abrupt revolution in the tenor and rhythm of the national life," and Professor J. U. Nef says "the rise of industrialism in Great Britain can be more properly regarded as a long process stretching back to the middle of the sixteenth century . . . than as a sudden phenomenon associated with the eighteenth and early nineteenth centuries." As a matter of fact, the traditional date—1760—assigned to the beginning of the Industrial Revolution precedes by nearly ten years Watt's improvement of Newcomen's engine, and by some twenty-five years Boulton and Watt's manufacture of the double-acting rotative steam engine as a regular product for mills and factories. These well-ascertained historical facts are more than sufficient to rebut the common assertion that the steam engine was the prime cause of the Industrial Revolution. Their importance lies in the evidence they present that the revolution had begun before the introduction of steam power into factories and must, therefore, be attributed to other causes. Those causes can be studied in the pages of industrial historians; to outline them even briefly would take more space than we have at our disposal.

In our own day we have frequently heard from the lips of churchmen and others lamentations over the invention and development of the internal combustion engine. Just as the Jeremiahs of the Industrial Revolution wept over the downfall of an idyllic England, so do those of the present shed tears for a whole world brought to the verge of misery by internal combustion! No one attempts to conceal the evils that accompanied the Industrial Revolution, though few notice that they were not of long duration and that factory conditions were little, if any, worse, and not infrequently better, than those that prevailed in home industries. Nor can similar charges be levelled against the internal combustion engine, for it must be admitted that the methods of manufacture of the smaller types of engine have caused refinements in factory equipment and methods that without them might be rare, if not unknown. Oddly enough, a traditional date—1830—is usually ascribed for the end of the Industrial Revolution. Yet in the light of economic history it is more rational to record a constant progression, or evolution, from, let us say, the Middle Ages, right through the development of water power, steam power, and gas power, up to the incipient stages of nuclear power. Revolution is a word too alarming to use for a natural sequence.

THE STATUS OF THE ATOM BOMB

WITH the demonstration over Japan of the immense potency of the uranium bomb, the dramatic termination of the second World War broke suddenly on an astonished world; a world endeavouring ever since to adjust itself, not very successfully, to the new situation. The public everywhere had to make up its mind, as best it could, whether this novel weapon represented a complete break with the past. What was its status? Was it something which would make previous modes of warfare entirely obsolete or was it just a new, and terrific, addition to man's armoury? Was it conceivably an inhumane weapon, not to be used at all? Following the fable of the Fox that lost its Tail, those Powers that had had no hand in its design and production inclined, of course, to take the latter view.

The United States offered in a very generous, if perhaps not very farseeing, gesture to abandon entirely the use of the new bomb if all other powers would do the same and would agree to the setting up of a strict international system of control and management of the whole process of uranium fission. Most countries welcomed the idea, but the U.S.S.R. and its satellites refused to agree, since they objected *in toto* to the creation of an international authority having under its control a body of internationally appointed inspectors with power to travel freely about any country in order to carry out their supervisory duties. The discussions which followed lasted for several years, but gradually petered out in view of the basic lack of faith in the possibility of creating sufficient international goodwill for any such plan to succeed In the meantime, the U.S. Government continued the gradual manufacture of atom bombs as a safeguard against any trouble in the future in which such weapons might prove useful. The subsequent course of events proved that this precautionary action was exceedingly wise, and it was not long before so experienced a judge of military matters as Mr. Churchill expressed publicly his opinion that it was only the existence of the growing U.S. stock-pile of atom bombs that restrained an aggressive invasion of Western Europe by the huge armies of the U.S.S.R. It was to be expected that within a few years the U.S.S.R. technicians—with some German help, no doubt—would succeed in making atom bombs for themselves; when this duly happened the situation was changed. But it was not greatly changed, since the

U.S.A. had had a long start and its rate of production was so considerable that a late comer in the race would be bound to be at severe disadvantage. Estimates quoted last year in the pages of the Chicago *Bulletin of Atomic Scientists* forecast a probable Russian stock-pile rising to 300 or so by 1955, compared with a U.S. one running into four figures. Then, in January, 1950, came President Truman's impressive announcement of the intention to proceed with the production of a hydrogen bomb. This even more powerful weapon was to be created not by the fission of heavy elements, but by the fusion of very light ones. Great as must be the difficulties to be overcome in its construction—for example, the attainment of a temperature of enough millions of degrees for a sufficient number of millionths of a second—it seems on the whole likely that it can be made. If it can, each single bomb may well prove as powerful as a thousand uranium ones, just as the uranium bomb is roughly equal to 1000 normal T.N.T. bombs. The amazing possibility of there thus being added to U.S. military strength a form of bomb a million times as powerful as those used over Britain and Germany during the last war, raises urgently the question of the new status of the several types of atom bomb, judged both from the belligerent and the legal (and humanitarian) points of view.

The status of the hydrogen bomb was discussed last year by the Atomic Energy Study Group of Chatham House, the London centre of the Royal Institute of International Affairs, and an address was given subsequently in public meeting by Professor Sir George Thomson, in which, while suggesting that the uranium bomb could properly be classed as an extra-powerful "normal" bomb, its hydrogen fellow was unnecessarily powerful for any purpose and likely if its metal casing happened, by accident or design, to be of a neutron-attracting kind to prove on explosion so poisonous to the earth's atmosphere as to endanger life on much of the earth's surface. Its banning by civilised nations was therefore proposed. But in July of last year there appeared a short, ably written book by a well-known American writer—W. L. Laurence—which argued that the hydrogen bomb, when designed to be entirely free from any poisonous effect, should be accepted as part of a normal bomb armoury, since if it were it would afford a potent weapon of defence for use by any country threatened by a large hostile army collecting on its frontier. Indeed, in his view, had the Nazis possessed even one such bomb during the invasion of Normandy it alone could have wiped out the entire invasion army even before it landed; and he claimed that this type of H-bomb, since it is so potent a weapon for the annihilation of armies, is probably the most effective deterrent against war that could be devised in the present state of affairs. If military opinion confirms this view, it would follow that it is only the poisonous form of this bomb, which Mr. Laurence terms the "rigged" type, which should be banned; though it is conceivable that in law it is so already under the Geneva convention of 1925 forbidding the use of poison gas. In which case its status is already settled.

Obituary

A. H. MUNDEY

THERE are many engineers and metallurgists who will learn with deep regret of the death of Mr. Alfred Holley Mundey, which occurred at his home at 14, Wrottesley Road, Plumstead Common, S.E.18, on July 5th, at the advanced age of eighty-three. For many years he had been actively associated with Fry's Metal Foundries, Ltd., of which he was a director.

In his youth, Mr. Mundey was an apprentice in the Royal Gun and Carriage Factory at Woolwich, where he subsequently rose to the position of chief metallurgist. In that capacity he was responsible for the metallurgical control of the factory's maufacturing operations. For some time Mr. Mundey was an evening lecturer at the Northampton Polytechnic Institute, and it was through his lectures there that he came into contact with Mr. John Horace Fry, who was then a student. It was largely the enthusiasm inspired by Mundey's lectures that led Mr. Fry to set up in business as a manufacturer of printing metal, and when Mr. Mundey left Woolwich Arsenal he joined the staff of Fry's Metal Foundries, Ltd., and was appointed one of its first directors. He was also a director of Fry's Diecastings, Ltd., and the Atlas Metals and Alloys Company, Ltd. Mr. Mundey's earlier work with Fry's Metal Foundries undoubtedly did much to put the manufacture and use of printing metals on a scientific basis.

During his career Mr. Mundey did a great deal to further the work of the Institute of Metals. When the Institute's autumn meeting was held in London in 1924 he acted as the reception committee's honorary secretary, he was chairman of the London local section in 1927–28, and served on the Council of the Institute from 1930 to 1938. He contributed several papers dealing with white metals, diecastings and other subjects to the "Proceedings" of the Institute of Metals and was the author of a book on "Tin and Its Uses." He was also closely associated with the formation of the Printing and Allied Trades Research Association in 1936, and was the first chairman of its research committee, an office which he held until 1946.

Throughout his long years of residence there, Mr. Mundey rendered much helpful service in the district in which he lived. During the last war he was a district air raid warden and established in the basement of his house a well-equipped control room and rescue apparatus store. His public work included also the chairmanship of the Board of Governors of the King's Warren School, Plumstead. In these and all his other activities Mr. Mundey showed his unfailing courtesy and genial personality. There are many who will long remember his friendliness and his ready assistance.

SIR THEODORE THOMAS

SIR THEODORE THOMAS, whose death, we regret to record, occurred at Eastbourne on July 3rd, spent the whole of his working career in the service of London's transport systems. From 1943 until his retirement two years later he was general manager of the London Passenger Transport Board. Theodore Thomas was born on February 9, 1882, and was educated at the Battersea Grammar School. At the age of seventeen he entered the drawing-office of the London United Tramways Company at the time when the horse tram services were being converted to electric traction. He was subsequently appointed a resident district engineer of the company.

When control of the London United Tramways Company passed to the Underground Group, Sir Theodore transferred to publicity and commercial work for the group, and in 1913 became commercial assistant to Mr. Frank Pick. In that capacity he was responsible for fares, routes and other commercial matters concerned with the acquisition of the London General Omnibus Company. In 1917 Sir Theodore left the Underground Group on being appointed development superintendent of the London County Council tramways, becoming traffic manager in 1925 and general manager in 1930. With the establishment of the London Passenger Transport Board in July, 1933, he was appointed general manager of tramways in the central, southern and eastern districts, and, a few months later, general manager of the Board's entire tram and trolleybus system. In 1936 Sir Theodore took over also responsibility for the operation of buses and, three years later, of railways as well as road services, taking the title of general manager (operation).

Sir Theodore was created a Knight in 1946, having received the C.B.E. in 1941 for his work in connection with the organisation of London's transport services in the early years of the war. He was a past-president, founder member and gold medallist of the Institute of Transport, and a past-chairman of the Public Transport Association.

Literature

An Introduction to Experimental Stress Analysis. By G. H. LEE. London: Chapman and Hall, Ltd., 37, Essex Street, W.C.2. Price 44s.

Handbook of Experimental Stress Analysis. By M. HETENYI. London: Chapman and Hall, Ltd., 37, Essex Street, W.C.2. Price 120s.

IT is unusual to find two new books on the same subject from the same publisher. Both these books cover completely all the techniques used in the practical determination of stress distribution, but are so different in presentation that they serve quite separate needs.

The smaller book is based on a comprehensive course of lectures given to engineering students. The author, Professor G. H. Lee, has a lucid style in print which makes his book interesting and easy to read. He displays his wide experience as a teacher in giving just as much as the average competent engineer can absorb. Also, in the conversion of his lecture notes to print for a wider public, he has not forgotten that his readers will not have the benefit of practical experience in his laboratory and has given in consequence a wealth of illustration and careful description. Professor Lee is a leading authority on photo-elasticity, and it is excusable that he has not quite managed to reduce the relevant chapters to their correct relative proportions. The discovery of two almost identical photographs in this section, separated by forty pages, gives an impression of unnecessary repetition. This and a misquotation of Saint-Venant's Principle are the only faults in a book that is ideal not only for the engineer embarking on laboratory work, but equally for any engineer who wishes to widen his knowledge.

By those for whom Professor Lee's book is ideal Professor Hetényi's book will be regarded with disfavour. It is too weighty, both literally and metaphorically, for the average engineer besides being beyond his

pocket. As may be expected of an edited collection of contributions from acknowledged experts, condensed to give the maximum of information in the minimum of space, it has as little continuity as an encyclopædia. Not that Professor Hetényi has failed in his object. There is no intention of giving a broad picture of the subject as a whole, nor is it his purpose to entice the casual peruser to read even to the end of the chapter. No concessions are made because the reader may not have had a university education. The book is factual, profusely illustrated and very well referenced. It deals with enough of the theoretical side at least to prove that one hour in the laboratory needs two at a desk, but it is in no way a substitute for the library that is a necessary adjunct to any laboratory.

In fact, at first sight, it appears to fall between two stools, being too advanced and bulky for a student and inadequate for the research man. There is, however, one shelf where it will find a place. Experimental stress analysis outside universities is now a matter of teamwork carefully co-ordinated and controlled. Much time and money can be wasted by duplication and ignorance of progress elsewhere. The task of direction leaves little time for the acquisition of personal expert experience in all the techniques that can profitably be used, nor is it always possible to devote the necessary time required to find and consult the right books in a library. It is in these circumstances that the "Handbook of Experimental Stress Analysis" is invaluable. One might well say, if you want to know about experimental stress analysis you need Lee; if you are actively engaged in it, you need a library, and if you ever have to direct it, you can just make do with Hetényi.

SHORT NOTICES

Industrial Polishing of Metals. By G. F. Weill. London: Iliffe and Sons, Ltd., Dorset House, Stamford Street, S.E.1. Price 21s. net.—This book opens with a brief historical survey of the metal polishing craft and its development. Then, after dealing with the theory of polished surfaces and the procedures for polishing different materials, it covers in some detail polishing technique and describes the plant, materials and other equipment used. A number of the defects that commonly arise in polishing are discussed and methods of avoiding or overcoming them put forward. Other chapters contain practical information on the extraction of metal dust and other health and safety precautions; on the costing of polishing work carried out commercially; and on some of the problems likely to arise in the average polishing shop. The book contains much useful information for all concerned with industrial polishing, whether as operators, managers, buyers or designers.

Workshop Technology, Part III. By W. A. J. Chapman, Ph.D., M.I.Mech.E. London: Edward Arnold and Co., 41, Maddox Street, W.1. Price 30s. net.—The two first parts of this series were published some years ago and the new volume brings the information given in them up to date and extends the scope of the work. It is intended for use with the previous volumes as a textbook for students working for Ordinary and Higher National Certificates and other advanced examinations. After dealing with materials and their testing, treatment and properties, the book goes on to describe their processing and the machines and tools used. Detailed information is given on measurement and inspection and the design and operation of lathes, milling machines and other machine tools. The recent developments in jigs and fixtures and screw thread production and measurement are described, and the book concludes with a chapter on the installation and maintenance of equipment. Students will find this new book a worthy companion to its first two parts.

Letters to the Editor

(We do not hold ourselves responsible for the opinions of our correspondents)

SELECTION OF INDUSTRIAL RADIOGRAPHERS

SIR,—I just obtained a copy of Dr. Pullin's article on "The Selection of Industrial Radiographers," which appeared in your January 26, 1951, issue, pages 116–17. I agree 100 per cent with Dr. Pullin's view. Like him, I feel strongly that it is the responsibility of the leaders in our field to see to it that this important inspection tool finds proper application. Like a Stradivarius in the hands of an amateur, the best radiographic facilities are wasted when operated by inexperienced men. It is just as important to employ well-trained brains as it is to have the right tools available, but it is more difficult to obtain these brains than it is to purchase equipment and materials. Needless to emphasise the importance and responsibility of the work done by the radiographic operator, or industrial radiographer (I.R.), as we prefer to call the man in charge of radiographic inspection work. It is his job to perform the operation as well as to interpret the results. Unless he has had a good education, extensive experience and specialised training he will not be able to do a perfect job. While the education may not be more than technical high school training, his experience should comprise at least two years of assistantship with a qualified I.R. After his practical experience he can take special training courses in industrial radiology. He then should pass an examination by a qualified radiologist before obtaining a certificate permitting him to call himself an I.R. The next step is the industrial radiologist. While his educational background may vary, he should have at least ten years of practice as an I.R. before he can be considered to be radiologist. While these are just a few thoughts, it may be that Dr. Pullin can elaborate on them and maybe some day the workers in our field will find the standing and recognition they deserve.

HERBERT R. ISENBURGER

St. John X-Ray Laboratory,
Califon, N.J., June 20th.

PRESENT-DAY LOCOMOTIVE WORKING IN GREAT BRITAIN

SIR,—Your correspondent, Mr. P. W. B. Semmens, in his letter appearing on page 867 of your issue of June 29th, refers to the use of a spring to help balance the uneven weight on the reversing shaft, and by implication apparently regards this as an innovation. The former Great Western, on their two outside cylinder types, using Stephenson's link motion, embodied this spring balancing device for over thirty years, maybe much longer, and I have an idea that it has been utilised on other railways, too.

K. N. HARRIS

Wealdstone, Middx,
July 6th.

The British Transport Commission's Report

THE third report of the British Transport Commission was published last Tuesday evening as a White Paper. Under the Transport Act, 1947, the report is made to the Minister of Transport. It deals with the year ended December 31, 1950. By that date the total deficit accumulated on the net revenue account in the three years since the Commission began operations amounted to £39,600,000. The deficit for the year 1950 was £14,100,000, compared with £20,800,000 in 1949, and, the report says, it "might have been avoided altogether if the adjustments in charges eventually made had been authorised earlier." In the closing months of the year the Commission's budget was almost in balance, but this balance was disturbed once more by a sudden jump in transport costs, both rail and road, including increased rates of pay amounting to about £20,000,000 in a full year.

Dealing with the future, the Commission calls in its report for the provision of finance on a large scale to replace and develop the national transport system. It says that if a large part of the system is not to stagnate or even decay, a more adequate allocation out of the total national capital investment will be required. There is also emphasised the need for greater willingness to accept changes, whether in conditions of work or in types of service or in proposals to integrate services. Costly delaying action, the report declares, on each proposal for reorganisation must be avoided. The Commission also expresses the necessity for a scheme of public control over fares and charges which is both speedy and flexible in operation.

All the Commission's passenger carrying activities were affected during 1950 by a fall in the spendings of the public, but freight services, the report says, showed a marked resilience. Railway freight traffics remained at much the same level after the increase in charges, and freight traffics on the road were also maintained at a high level, in spite of the increase in road haulage rates. Gross passenger receipts in 1950 totalled £206,600,000, or £5,200,000 less than in 1949. Gross receipts from freight traffic increased to £305,900,000 last year.

At the end of the year the total number of employees in the Commission's undertakings was 888,448. On British Railways, after making adjustments for transfers from or to other Executives, the number of staff employed had been reduced since July, 1948, by about 55,000. Those reductions represented, however, in part, shortages in certain grades, particularly permanent way maintenance staff.

Information of particular interest in the report is that which deals with the activities during the year of the various Executives. Progress made with railway electrification schemes is noted, and there is reference to the other engineering activities on British Railways. During the year, 1275½ miles of railway track were completely renewed, the use of mechanical plant for track relaying and maintenance being further developed. Four trial schemes of mechanisation of day-to-day length gang maintenance were planned for introduction this year. In addition, the report says, a works control system for the better organisation and use of labour was introduced and is being extended during the current year. During last year the Railway Executive had planned to construct and put into traffic 436 locomotives; 327 to be built in the railway shops and 109 by private firms. The actual number completed and placed in service was 411, representing a deficiency of nineteen from the railway shops and six from contractors' shops. In addition, three electric locomotives for the Manchester-Sheffield-Wath electrification were completed. The reduced rate of permissible capital investment for 1951 made it necessary to postpone until 1952 a number of locomotives which it was originally intended should be built this year.

BOOKS RECEIVED

John Anderson, Pioneer of Technical Education, and the College he Founded. By James M. Macaulay. Glasgow: John Smith and Son, Ltd., 57–61 and 66, St. Vincent Street, Glasgow, C.2. Price 8s. 6d.

Industrial Research in Switzerland, Its Institutional and Economic Background. By Ronald S. Edwards. London: Sir Isaac Pitman and Sons, Ltd., Pitman House, Parker Street, W.C.2. Price 21s.

Ordinary Non-Linear Differential Equations (In Engineering and Physical Sciences). By N. W. McLachlan. London: Oxford University Press, Amen House, Warwick Square, E.C.4. Price 21s.

Molesworth's Handbook of Engineering Formulæ and Data. Thirty-fourth edition. Edited by Albert Peter Thurston. London: E. and F. N. Spon, Ltd., 15, Bedford Street, Strand, W.C.2. Price 32s. 6d.

The Royal Show at Cambridge

No. III—*(Continued from page 22, July 6th)*

THE Royal Agricultural Society's Show at Cambridge ended on Friday last. During the four days on which the Show was open the weather was fine and the ground conditions were good. The machinery and equipment exhibits were more extensive than at last year's Show, which was held at Oxford, and were well displayed on the 150-acre site at Trumpington, 2 miles from the City of Cambridge. The paid admissions on the four days of the Show totalled 131,333, compared with 122,236 at Oxford last year, and 92,352 in 1922, when the Show was last held at Cambridge.

New Implements

Fifteen new implements were finally accepted by the Royal Agricultural Society for adjudication for silver medal awards. The judges were Mr. W. Newcombe-Baker and Mr. Roland Dudley. Silver medals were awarded to Harry Ferguson, Ltd., for the mounted reversible plough described in our issue of June 29th; to Rotary Hoes, Ltd., for the Howard potato haulm pulveriser, and to Gascoignes (Reading), Ltd., for the "Rotor Freeze" milk cooler. This last-named item of equipment also gained the first award of the Perpetual Challenge Trophy, presented by Sir Roland Burke.

We conclude, in what follows, our descriptions of some of the implements and machines exhibited at the Show.

Teles Smith, Ltd.

In Fig. 12 there is illustrated a lightweight power driven chain saw which has been designed by Teles Smith, Ltd., Iddesleigh House, Caxton Street, London, S.W.1, primarily for estate owners and foresters who may have to deal with medium sized

Fig. 12—Lightweight Chain Saw—Teles Smith

timber. The makers—on whose stand the saw was exhibited—emphasise that no special skill is required for its operation. The machine weighs only 68 lb, and its maximum cutting width is 24in. The power unit is a two-stroke Villiers petrol engine, developing 4 b.h.p. A multi-disc clutch, operated by a lever placed on the handle-bars opposite the throttle control, enables the engine to run whilst the saw is idle. The saw chain consists of a series of fast cutting teeth which, incidentally, can be sharpened with an ordinary mill-saw file. By the operation of a single lever, the guide bar, or the saw chain track as it is sometimes called, can be swivelled into any desired cutting angle, an arrangement which has been made to eliminate adjusting lock-nuts. It is thus possible to change over quickly from an oblique cut to a horizontal cut, as is necessary when felling a tree. The guide bar can also be swivelled into a vertical position to enable a tree to be cross-cut from underneath.

A larger saw of similar construction was among this firm's exhibits. Its weight is about 130 lb, the power unit being a Villiers two-stroke engine, designed to develop 6½ b.h.p.

Bamfords, Ltd.

Bamfords, Ltd., Uttoxeter, Staffs, is one of the oldest Royal Show exhibitors, and its display this year included a representative selection of implements and oil engines specially suited to work barn and farmyard machinery. Most of the implements shown

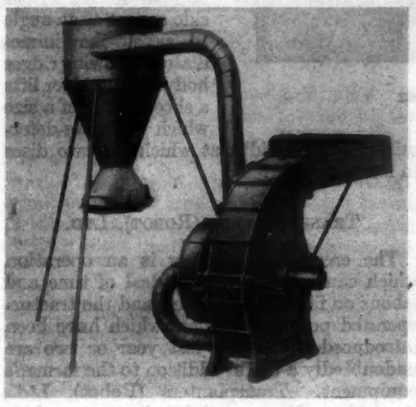


Fig. 13—Hammer Mill—Bamfords

have been designed—as is usual these days—for work with tractors, but, among its grass mowers, Bamfords, Ltd., exhibited two horse-drawn machines. One of them, which can be worked by a single horse, is fitted with a 3ft 6in cutter bar. The mower has a two stage transmission gearbox with machine cut gears, a vertical lift for the cutter bar, and a solid one-piece axle actuated by grease packed pawls in the hubs of the road wheels.

A tractor side rake, which the firm has recently put into production, has reversible bevel gearing of a new design, which gives a speed for side raking and turning two swaths and a quicker reverse action for tedding. The gearing has only one set of teeth, the two speeds being obtained by the use of unequal sized pinions mounted on the reel driving shaft. The gears are engaged by a sliding clutch. The rake has four arms disposed behind the road wheel axle and they are fitted with removable centres for swath turning.

Among the barn machinery shown by Bamfords, Ltd., was the "Rapid" hammer mill, illustrated in Fig. 13. It is intended to deal with practically all kinds of material in dry condition. The body of the mill is made from high-duty cast-iron, the top half being hinged to allow inspection or adjustment of the working parts. The casing for the 24in diameter six-blade fan is separate from the mill but is secured to it by studs passing through circular lugs on the mill body. There are twenty-four swinging hammers arranged in eight rows on a rotor mounted on the main driving shaft, which runs in self-aligning ball bearings. The fan draws the ground material through a screen, 465 square inches in area, and elevates it to a cyclone with two outlets controlled by a flap to enable one bag to be changed while the other is being filled. For regulating the feed to the mill, two adjustable slides have been provided in the hopper. The normal speed of the mill, which is belt-driven, is from 1800 to 2000 r.p.m., the power required being 18 to 20 b.h.p.

Ransomes, Sims and Jefferies, Ltd.

One of the new implements on which the judges deferred their decision until next year was a mounted reversible plough, exhibited by Ransomes, Sims and Jefferies, Ltd. It is being produced by that firm in co-operation with the Ford Motor Company, Ltd., and is a two-furrow implement with steel or pneumatic-tyred depth wheels. The plough has been designed for use with the Fordson "Major" tractor, the reversing action being effected by a long lever which is within easy reach of the driver. The plough legs are adjustable for ploughing widths of either 11in or 13in, the depth being varied by a screw mechanism operating on the depth wheels.

The export section of this firm's exhibits included a 30in maize sheller, which is illustrated in Fig. 14. The machine is capable of husking and shelling maize at the same time, or shelling only, and in favourable conditions is able to produce from twenty to twenty-five 200 lb bags of husked and shelled corn an hour. The machine has a welded steel frame mounted on steel wheels. Its working parts include a two-bladed helix which revolves in a cage built up of steel rings and bars, and two well-balanced groups of sieves, which constitute the separating "shoes." They are operated by a double-dipped crank and work in opposite directions. The upper shoe is arranged so that maize passing through the cage bars does not mix again with the leaf refuse. The sieve area is thus given over entirely to separating the maize from the leaf and cob passing through the cage outlet. In the lower shoe there is an extra long combined cob and chaff sieve,

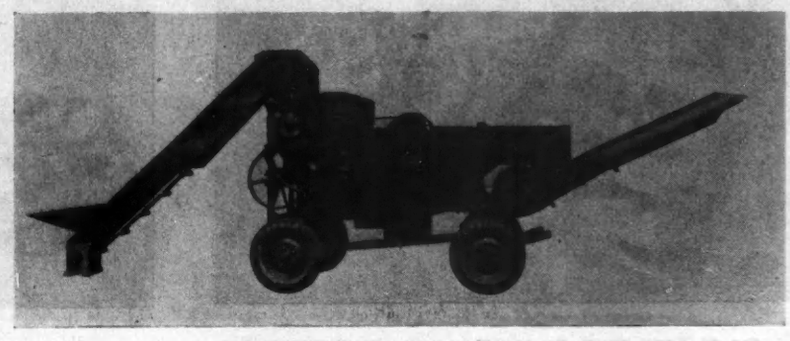


Fig. 14—Maize Sheller—Ransomes, Sims

and six alternatives are provided for dealing with different conditions of maize. Sieve plates in the lower floors of this shoe grade out the small and broken maize. A bagging elevator, consisting of buckets on an endless belt, is fitted, and there is a refuse blower which takes all leaf and cob from 20ft to 30ft away from the machine. Light refuse is removed from the grain by a large fan, which also sends a blast of air through the sieve of the upper shoe where beard is liable to collect and choke the perforations. The cobs are fed into a steel hopper and are elevated to the cage inlet by an impregnated rubber belt with renewable wood carriers. The speed of the helix is 910 r.p.m. and the power required for driving the machine is not less than 10 h.p. to 12 h.p.

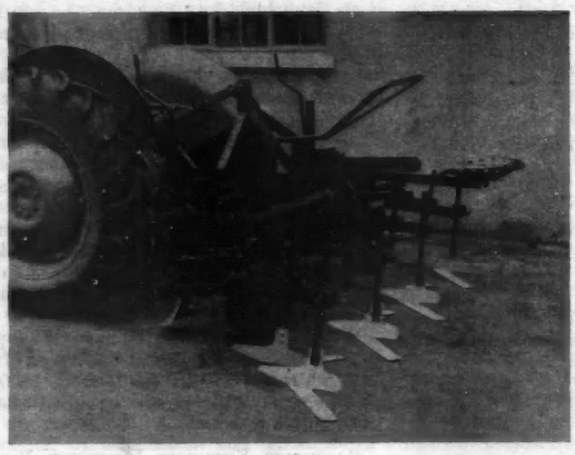


FIG. 15—STEERAGE HOE—TWOSE

E. V. TWOSE, LTD.

In an article describing the new works of E. V. Twose, Ltd., Tiverton, published in our issue of June 22nd, we referred to the various implements which this firm is now manufacturing. They were on show at Cambridge last week, and included the steerage hoe illustrated by Fig. 15. This implement is an attachment to the tool bar which the firm has designed to work on the hydraulic lift of a number of tractors, and is being produced in three, four and five-row sizes. Each hoe blade is independently spring loaded to counteract any obstruction that may be encountered in work, and the blades are shaped in such a way as to prevent the soil they shift covering the plants. The required lateral adjustment of the hoe is effected by a hand lever controlled by an operator seated at the rear of the implement.

Another mounted implement shown on the stand was the shallow ditching machine which the firm has recently designed. Its purpose is the rapid digging of drainage trenches to take away surface water. The implement has a square frame with lateral and longitudinal members of between 2ft and 3ft. The three discs which are carried at the front of the frame are placed so that the centre one is vertical and those on either side are set at an angle to assist the immediately following ridger body. The ridger lifts a slice of turf of a size which is pre-determined by the width at which the two discs in front are set.

TRANSPLANTERS (ROBOT), LTD.

The erection of fencing is an operation which can take up a good deal of time and labour on farms and estates, and the tractor-operated post hole diggers which have been introduced within the last year or two are undoubtedly a useful addition to the farmer's equipment. Transplanters (Robot), Ltd., Sandridge, Herts, exhibited a post hole digger which it has designed for use with the David Brown "Cropmaster" tractor. The weight of this implement, a photograph of which is reproduced in Fig. 16, is just over 500 lb. Augers in three different sizes are available, 6in, 9in or 12in diameter, all of them boring holes to a depth of 36in. The auger is attached to its frame by a swivel joint to ensure that on sloping ground the holes are bored vertically. The motive power for the auger is applied through a totally enclosed crown wheel and pinion driven by a telescopic shaft from the power take-off of the tractor. To prevent damage to the digger or the tractor, a slip clutch has been fitted on the power take-off shaft. The implement is mounted to the tractor by the three-point hydraulic linkage, the hydraulic lift raising it clear of the newly bored hole for transport to its next point of operation.

Another of this firm's mounted implements which attracted attention at Cambridge was a seed planter for the single or grouped seeding of maize, peanuts, beans, sugar beet and similar crops. The implement is also fitted with a fertiliser distributor, which will place granular fertiliser in a band about 2in away from the planted seed. The drill is constructed on the unit principle, each unit having two hoppers, one for seed and the other for the fertiliser, the drive for both being taken from the rear land press wheel through a chain and sprockets. There are two sowing rate adjustments on the fertiliser hopper and there are twin feed plates inside the seed hopper to vary the drilling as required by the different seeds being dealt with. The opening share and press wheel for each unit are separately articulated to give accurate working when the ground is uneven.

MASSEY-HARRIS, LTD.

The stand occupied by Massey-Harris, Ltd., Stretford, Manchester, contained an effective display not only of tractors and implements manufactured in its British factories, but also some of the productions of its overseas establishments. One implement of particular note was a bedder-cultivator, mounted to the "pedestal" design of Massey-Harris 744D tractor. Independent beams and individual gauge wheels permit the cultivator feet to follow the contour of the ground. The implement has a clearance of 25in, thus making it suitable for the late cultivation of such tall-growing crops as maize, sorghum or cotton.

Among the tractors shown on the stand was one named the "Pony," which is now in production in the company's factory in France. This tractor, which is intended primarily for work in Eastern countries, is powered by a four-cylinder heavy-duty overhead valve four-stroke petrol engine of 72mm bore by 72mm stroke. The governed speed of the engine is 1000 to 1800 r.p.m. Transmission is by sliding spur gear, with heavy drop gear drive to the main axle. There are three forward speeds, between 2·74 m.p.h. and 7 m.p.h., with the engine running at 1800 r.p.m., and a reverse speed of 3·22 m.p.h. The rating of the tractor is 15 h.p. when working a two-furrow plough with 12in bottoms. The tractor can be equipped, if desired, with a power take-off

FIG. 16—POST HOLE DIGGER—TRANSPLANTERS (ROBOT)

FIG. 17—POTATO PLANTER—MODERN DESIGNS

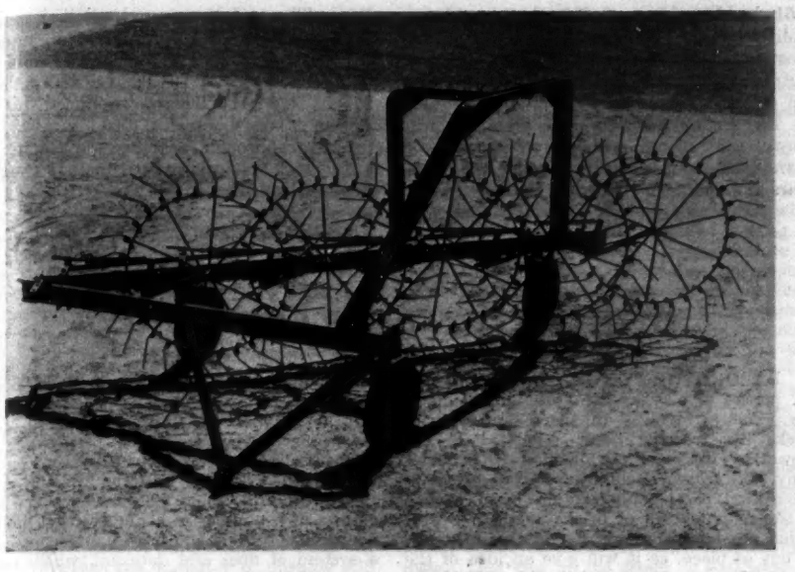


FIG. 18—SIDE RAKE AND SWATH TURNER—BLANCH

shaft and pulley, hydraulic lift, and a tool bar for implements.

MODERN DESIGNS, LTD.

For some time past Mr. P. J. Packman, of Modern Designs, Ltd., Twyford, Berks, has been working on the development of a potato harvester, which received a silver medal award at the 1948 Royal Show. The harvester was among the firm's exhibits at Cambridge, where there was also shown the latest version of the Packman potato planter, illustrated in Fig. 17. The planter can be attached to the hydraulic linkage of a tractor, a development which facilitates its operation. It is a three-row machine assembled on a tubular frame equipped with pneumatic-tyred wheels. The potato receiving buckets are grouped on a rotor assembly, which is belt-driven from the ground wheels. At the feeding position the buckets are grouped close together and as the rotor turns they are automatically spaced apart at the planting position, the result being that the potatoes are placed on the ground and not dropped. Operators seated on the rear of the machine feed the seed cups from conveniently situated trays. The centre planting unit is permanently fixed to the cross members of the implement, but the two outer units are adjustable in their frames to permit row widths of 26in, 28in and 30in. The belt drive from the main wheels to the rotor runs on a triple vee-pulley at the wheel end and a double vee-pulley at the rotor end. Double covering ploughs are fitted to the rear cross-member of the implement.

A. B. BLANCH AND CO., LTD.

A rather unusual haymaking implement, which was exhibited by A. B. Blanch and Co., Ltd., Crudwell, Malmesbury, Wiltshire, is the "Revolution" side rake and swath turner, illustrated in Fig. 18. This machine, incidentally, was one of those accepted for adjudication as new implements. It consists of a triangular frame, constructed of "I" section steel, joined at one end by an arch. From the frame, which is equipped with three pneumatic-tyred road-wheels, five wheels are mounted on independently sprung axles and around the periphery of these wheels single-leg tines with an angular set are fitted. A single lever lifts all five tined wheels when required and when the machine is in work they are lowered by the same lever to make contact with the ground. The wheels, being set at an angle to the forward direction of the machine's travel, revolve and the crop is thus moved across by the tines. The machine is able to cover two 5ft or 6ft swaths. When swath turning, the centre tined wheel is replaced by a swath-board to prevent the rear pair of tined wheels catching the swath, which is being turned by the foremost pair.

ROTARY HOES, LTD.

In the business of mechanised potato harvesting difficulty is often experienced in the clearing away of haulm and weed-growth. Such growth can clog the elevators of harvesting machines. Rotary Hoes, Ltd., East Horndon, Essex, has designed a haulm pulveriser working on the "Rotavator" principle. For it the firm was awarded a silver medal by the Royal Agricultural Society last week. A rear view of the machine is shown in Fig. 19. At present it is being produced for operation by the power take-off of the Fordson "Major," Ferguson and David Brown tractors. The working width of the machine is two 30in rows at a time. Its controls consist of a hand lever dog clutch, which puts the rotor into gear, and a depth control wheel. Lifting is by the normal hydraulic mechanism of the

FIG. 19—HAULM PULVERISER—ROTARY HOES

tractor and the pulveriser is driven directly from the tractor's power take-off shaft through a Hardy Spicer universal coupling. The blades are set at angles to follow the contour of the land baulk, and with the rotor revolving an inch or two above the ground at a speed of 600 r.p.m., haulm and weed growth can be effectively chopped and broken up.

FORD MOTOR COMPANY, LTD.

When the Royal Show was last held at Cambridge, there was exhibited the Fordson 22 h.p. tractor, which was first brought to this country in 1917. This year, the Ford

FIG. 20—THE IVEL TRACTOR, 1902

Motor Company, Ltd., Dagenham, Essex, showed the latest developments in its range of tractors including the rowcrop and standard agricultural models of the Fordson "Major." The big selection of implements included the mounted two-furrow and three-furrow disc ploughs, an example of which is displayed in the Country Pavilion at the South Bank Exhibition and was illustrated and described in our issue of May 25th. The main frame of the plough is made up of heat-treated cast steel triangular sections. Provision is made for furrow width adjustment from 10in to 12in, the depth of work being controlled by a single depth wheel.

Ruston and Hornsby, Ltd.

A display of oil engines and pumps suitable for many agricultural duties was presented by Ruston and Hornsby, Ltd., Lincoln. It included a selection of horizontal engines as well as several vertical units. The firm also showed a sectioned two-cylinder, 22½ b.h.p. engine which it has recently produced for demonstration purposes. It is a fully sectionalised slow-running unit with enclosed lighting to show clearly the full cycle of the operation and the constructional features of the engine.

Parade of Tractors

An interesting event in the Grand Ring on three days of the Show was the parade of twenty-five small and large tractors, several of them with mounted implements. They included British and foreign machines and were thoroughly representative of the tractors now in use in this country and overseas. In addition, and in distinct contrast to these present-day machines, there was included in the parade, by courtesy of the Science Museum, South Kensington, the Ivel tractor of 1902, a view of which is reproduced in Fig. 20. The tractor, which is a three-wheeled machine, was built by Mr. Daniel Albone, of Biggleswade, and was first exhibited at the Royal Show in 1903, an improved version of it receiving a silver medal award a year later. The tractor illustrated has no radiator, but carries a 30-gallon tank in the cooling system. Its engine was designed to develop about 14 h.p., and there is a simple, but massive, cone clutch which gives one forward and one reverse speed. The speed-change control lever, locked in forward or neutral gear, requires to be held by hand, as a safety factor, when in reverse. At the present stage of agricultural tractor development, it is interesting to recall that when the Ivel tractor was exhibited in 1903, the principal objection of the machinery judges was the use of petrol as fuel. They emphasised the great risks incurred "by using such a dangerously inflammable liquid in or about the farmyard."

Historical Exhibits

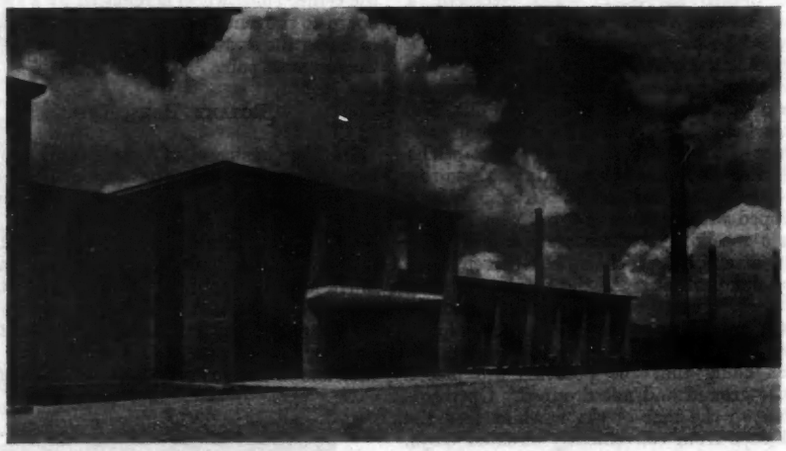
This Festival of Britain year has led to a quickening interest in the things of the last century, and there were numerous visitors to the excellent collection of implements in use on farms in 1851. Some of them, in fact, which were introduced about that time have only recently passed into retirement! The Royal Agricultural Society is to be congratulated on this display, in the arrangement of which it was ably assisted by the Museum of English Rural Life at the University of Reading. Items which particularly appealed to us were the portable steam engine, mounted on wooden wheels, and built in 1851 by Hornsby, of Grantham, and the replica of the one-horse reaping machine constructed by McCormick in 1831.

Another interesting historical display was the collection of veteran tractors assembled by *The Power Farmer*. The eight tractors shown were those which were introduced to the farms of this country during and in the years immediately following the first World War. Three of them were by British makers. They were the 25 h.p. Saunderson, made by the Saunderson Tractor and Implement Company, Ltd., in 1914; the 25 h.p. lightweight (28 cwt) tractor produced by the Austin Motor Company, Ltd., in 1923, and the Peterborough tractor, developing 29 h.p., which was constructed in 1919 by Peter Brotherhood, Ltd.

A Brick Research Laboratory

A LABORATORY for investigating the properties of clay used in brick-making and the processes involved in the manufacture of bricks has recently been completed at the Stewartby works of the London Brick Company, Ltd., near Bedford. Before giving a description of the laboratory a brief outline of the manufacture of bricks at these works, which are known as Fletton bricks, may not be out of place, as it will give an idea of the range of research activities with which the laboratory will be concerned.

The Stewartby works are said to be the largest brickworks in the world. The weekly production is at present about 10 million bricks. The raw material is a particular deposit of the Oxford clay, which was laid down probably at the mouth of rivers flowing into the Jurassic Sea, which covered England east of a line from the Yorkshire to the Dorset coasts.



Brick Research Laboratory at Stewartby

The beds worked lie around Peterborough, along the shallow valley, in which Stewartby is situated, and in small islands in Buckinghamshire and Oxfordshire. They are uniform in composition and are suited to mechanical excavation. The Stewartby pit needs to provide some 42,000 tons of clay per week for full output, which is dug by a single 10 cubic yard face shovel, working a face some 60ft in depth. The 15ft or 20ft of overburden is removed by a dragline, which tips the spoil into the hopper of a conveyor situated on the newly exposed clay stratum. This conveyor leads to a second much larger spoil conveyor of "hammer-head" form, which travels on rails along the quarry bottom, collecting the spoil from the first conveyor and dumping it well away from the working face. The face shovel loads the clay into a sorting machine, which reduces the larger lumps and loads the clay into trains of 6-ton wagons. The wagons are then shunted to a chain-loading station, where they travel by endless chain haulage gear to the works.

On arrival, they are emptied by tipplers into storage hoppers, feeding two lines of grinding mills, which reduce the clay to a fine powder. The powder is screened and delivered by belt conveyor to the line of brick presses below. The presses mould the powdered clay into bricks between heated dies and under four progressively increasing pressures. The "green" bricks so produced are strong enough to be loaded directly into the kilns, in which they are then stacked for burning. The kilns consist of a number of chambers each holding up to 40,000 or 72,000 bricks, and coupled by a system of flues and dampers, which enable the newly-stacked bricks to be dried and preheated by the waste heat from other chambers where the bricks have already been burnt. The kilns are thus continuous in operation, the chambers being successively filled, burnt and unloaded. The burning takes about two weeks, a point of interest in this particular method of brick-making being that the clay has an appreciable calorific value, of the order of 1000 B.Th.U. per lb, due to its organic content. This value is sufficient to supply all the heat required to burn the bricks, assuming 100 per cent efficiency of the kilns. In practice it reduces the coal consumption to about 1 cwt of coal for each 1000 bricks.

The Research Laboratories

The laboratory block, which has recently been erected at Stewartby, is shown in the accompanying illustration. Research work has been carried out by the company since the nineteen-twenties, but has increased in extent during recent years, thus calling for the new accommodation. The equipment ranges from a 200-ton Amsler compression testing machine to the variety of apparatus required in the analytical laboratories.

Although routine testing forms a substantial part of the work of the laboratories, there is much interesting research work to be done. It may be said that, broadly, the objects of research are twofold. In the first place the aim is to achieve a greater uniformity in the quality of the bricks and other products and so to improve their properties and to reduce the cost of manufacture. In the second place the work is aimed to meet the growing demand of the contemporary architect and engineer

for new building materials having specialised properties.

Fundamental research into the nature of clay minerals is basic to the full appreciation of the behaviour of clays used in the manufacture of clay products and work of this character is to be undertaken in the new buildings. Existing and new clay deposits of interest to the company are studied, by geological and boring surveys, to define their extent, and to test their suitability as sources of raw material. The physical properties of clays and their behaviour, when subjected to processes corresponding to those used in brickmaking, are being studied. The machines used to prepare the clay and to form the bricks are the subject of constant study. Much of this work involves operational research on full-scale production plant, for which quality control techniques are widely employed, but facilities are also available in the new laboratory for smaller scale work on brickmaking plant.

The carbonaceous material present in the Oxford clay is of considerable importance to the brickmaker, since its presence enables Fletton bricks to be burnt with only a relatively small quantity of extraneous fuel. In order to increase the efficiency of burning still further, its nature and characteristics are being studied. The data needed to design efficient kilns are obtained, both from studies of full-scale kiln operation and from laboratory experiments; flue and chimney design are of particular interest at the present time.

The work of the laboratory will also include the development of light-weight products, and products having improved thermal properties, as well as materials used in conjunction with brick, such as masonry mortars and colour washes. The economic use of by-products derived from brick manufacture is also receiving attention. We understand that the laboratories' work is not at present concerned with such subjects as bricklaying and the structural uses of brickwork, but these subjects are not neglected by the technical staff of the company. For instance, the size of bricks is governed by a British Standard Specification, which has recently been issued, although recent work on modular co-ordination would seem to indicate that the optimum size might be investigated. Another interesting subject is the use of reinforced brickwork, the best-known examples of which were probably the war-time surface air-raid shelters. It is perhaps worth mentioning in this respect that the use of prestressed brickwork is also under consideration.

Canadian Turbo-Jet Engine

THE first jet engine to be developed in Canada, the "Orenda," has flown in the Royal Canadian Air Force "CF.100" all-weather, long-range, twin-engined fighter at Malton, Ontario.

Both the engine and the aircraft, which are now to be produced in quantity, have been designed, developed and produced at Avro Canada's Malton Works in Ontario, by a team of Canadian and British engineers.

It is stated by the company that the "Orenda" has a rated thrust in excess of 6000 lb and a fuel consumption of approximately 1·00 lb per hour per pound thrust, both under sea level static condition. The "Orenda" has an axial compressor of combined disc and drum construction, six combustion chambers and a single-stage turbine. A flexible rubber thrust ring is incorporated, which permits angular misalignment of the centre bearing to cater for engine structure deflections during aerobatics. The nominal diameter of the unit is 42in and its length about 10ft, the dry weight being 2500 lb.

The "Orenda" engine project was started in September, 1946, and it first ran in February, 1949. The predicted performance was obtained about three months later, and the first engine ran 1000 hours in eight months with only minor modification. Flight testing was undertaken in a Lancaster bomber and a "Sabre" high-speed aircraft.

A 12in Hydraulic Pipe Bending Machine

OUR illustration shows a "Staffa" 12in hydraulic pipe-bending machine which is being made by Chamberlain Industries, Ltd., Staffa Road, Leyton, London, E.10. This machine is designed to bend solid drawn steel pipe 12·75in external diameter, with a maximum wall thickness of 0·375in, bending centres 8ft with a maximum angle of bend per stroke of 5 deg.

The machine consists of a central former or saddle, mounted on a hydraulically operated ram. The former moves between two end chain fixings, thus bending the pipe which is contained between the central former and the retaining chains. The ram unit, together with the end chain fixings, is contained in a box section beam which can be rotated by a worm and quadrant through 90 deg. This enables the pipe to be bent in a vertical or horizontal plane and at intermediate angles.

The main frame, which has an overall length of 13ft 2in, with a depth of 2ft 6¾in and a height of 3ft 2in, is of bolted and welded construction, the main members (two 8in by 5in rolled steel joists) acting as skids on which the machine rests. One end of the frame is extended to form a platform on which the power unit is mounted.

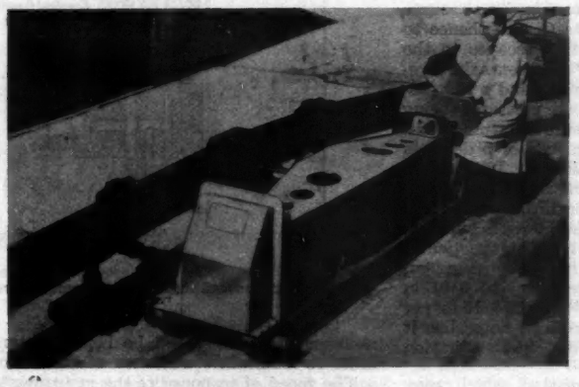
The bending beam is made up of ¾in plate welded to form a box section of maximum size at the centre and diminishing in two planes to form a 12in square box at each end, its overall length being 9ft.

Lightening holes and an inspection panel are provided. A heavy duty trunnion is welded into place in each end of the beam, the trunnion at the power unit end being hollow to permit the passage of two flexible pipes to the ram, and two cast steel chain fixing brackets are bolted at each end of the beam to give bending centres of 8ft.

The ram is of high-tensile steel, 5¼in diameter, with a full stroke of 12in. A forward thrust of 85 tons is developed, the maximum ram travel speed forward being approximately 3in per minute, and return speed approximately 8in per minute. The cast steel cylinder 7in internal diameter and 11in external diameter is designed to withstand a working pressure of 5000 lb per square inch.

The ram nose is designed to permit 5 deg. of movement of the former in any direction. This provision avoids kinking, as it enables the groove in the former to be tangential with the tubing.

The work is retained in position by two specially constructed pipe chains, with link pins of 1¼in diameter high-tensile steel. The cast steel chain fixing brackets are provided with a double set of retaining lugs to hold two pins at each end of the chain, as an additional precaution against failure. A fixing pin can be provided to hold one end of the chain permanently in position.



PIPE BENDING MACHINE

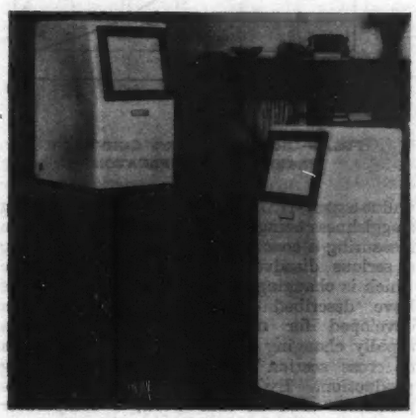
The power unit is a J.A.P. model 6 petrol engine, air cooled (forced draught), developing approximately 5 b.h.p. at 1800 r.p.m., or a 6 h.p. electric motor, and a Beacham two-stage hydraulic pump, driven by the motor through a vee belt reduction drive. The delivery is controlled by a handwheel giving a variation between zero and 120 cubic inches per minute, approximately. This enables the ram travel speed to be adjusted from zero to approximately 3in per minute maximum.

The flexible pipes in the hydraulic circuit are of synthetic rubber construction, with internal wire braiding between the two rubber sections to withstand a working pressure of 5000 lb per square inch.

The actual working time for cold and unloaded bends in 12in bore tubing is one 90 deg. bend per hour, as against two per day by the conventional "Jimcrow" method. This machine was originally designed to fit the requirements of a large oil company and its compact and narrow design renders it especially suitable for the bending of tube to large "sweeps" of about 25ft in situ, in the actual pipe trench. The approximate net weight is 2 tons 9 cwt.

An Automatic Loop Diascope

WE recently attended a demonstration of a fully automatic film loop diascope, known as the "Rotavisor," which is manufactured by Newton and Co., Ltd., 72, Wigmore Street, London, W.1.



THE "ROTAVISOR" DIASCOPE

The projector is a standard Newton diascope, suitably motorised and fitted with a high-pressure mercury vapour lamp. Due to the light intensity and the clarity of the image, the unit can be successfully operated in full daylight without the necessity for external shading. The 250W mercury vapour lamp has a light equivalent of a 1000W tungsten filament lamp and a life of about 500 hours.

The mechanism controlling the motion of the film loop is normally set so that each frame is projected for a period of twelve seconds. This timing is, however, variable and means are also provided for the prolonged examination of any individual picture. Normal operation is entirely automatic, and the "Rotavisor" may be switched on and left in service for long periods without attention.

Standard 35mm film strip is used, made up into loops of up to eighty frames. Loop absorbers may, however, be fitted where a greater number of frames are necessary.

As shown in our illustration, the "Rotavisor" is supplied as a table or console model, the weight of the latter being 85 lb.

A Pneumatic Comparator of High Sensitivity*

By M. GRANEEK, B Eng., A.M.I.E.E., and J. C. EVANS, B.Sc., Ph.D.

THE last decade or so has seen a marked increase in the use of pneumatic gauging in precision engineering, in workshops as well as in inspection and standards rooms. This technique has especial advantages for some applications, e.g., the measurement of fine bores, and has the particular merit that high sensitivity may be obtained with relatively simple apparatus. Increase of sensitivity has, however, in general, been attained only at an undue expense in speed of response, the resulting sluggishness being often a drawback even when measuring a constant dimension and becoming a serious disadvantage when measuring one which is changing fairly rapidly. The authors have described elsewhere[1], [2] apparatus developed for measuring and recording a rapidly changing quantity, such as the "area of cross section" of a textile yarn during production. By further development of the principles used in that work, a comparator having very high sensitivity and good speed of response has been devised in a compact and robust form, and this instrument is described below.

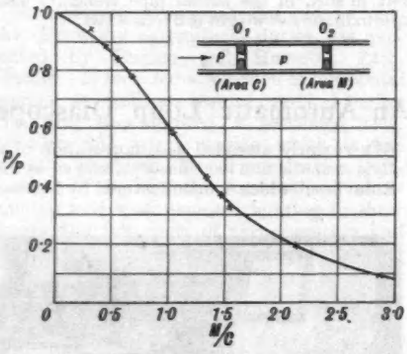


FIG. 1—CHARACTERISTIC CURVE OF PNEUMATIC COMPARATOR

THEORETICAL CONSIDERATIONS

It will be useful to consider first the principle of the particular form of pneumatic gauging employed and the factors which determine the working characteristics of an instrument based upon it. The principle is shown schematically in Fig. 1. Air from a constant pressure source is supplied first to an orifice O_1 and thence to an orifice O_2 through which it escapes to the atmosphere. The symbol P represents the pressure upstream of the first orifice and p that between the two orifices, both pressures being referred to atmospheric pressure as datum. For a given value of P, the magnitude of p depends on the relative sizes of O_1 and O_2. If C and M are the effective escapement areas of O_1 and O_2 respectively, the relationship between p/P and M/C is given by a characteristic curve of the form shown in Fig. 1. This particular curve was obtained experimentally using an orifice O_1 of fixed diameter equal to 0·033in and a constant value of P equal to 15 lb per square inch. It is of interest to note that it agrees quite closely with the equation $\left(\frac{M}{C}\right)^2=\frac{P}{p}-\frac{p}{P}$, an approximation which may be derived from theoretical considerations.

For values of p/P between 0·4 and 0·9 the characteristic curve in Fig. 1 differs little from the straight line represented by the equation,

$$\frac{p}{P}=1\cdot10-0\cdot50\frac{M}{C} \quad . \quad . \quad . \quad (1)$$

so that within these limits, and for constant values of P and C, p may be regarded as a linear function of M. If the effective area of escapement of O_2 is arranged to depend on a dimensional quantity A in such a manner that alteration of A produces a proportional alteration of M, then changes in A may be determined by measuring the corresponding changes in p.

The rate of change of p with M is given by the equation,

$$\frac{dp}{dM}=-0\cdot50\frac{P}{C} \quad . \quad . \quad . \quad (2)$$

and hence, for a given value of P, is greatest when C is least. The largest value of M/C within the linear range is that corresponding to p/P equal to 0·4, and, by equation (1), is equal to 1·40. For maximum sensitivity, therefore, C should be chosen so as to satisfy the relationship

$$C=\frac{M_{max}}{1\cdot40}=0\cdot7M_{max} \quad . \quad . \quad . \quad (3)$$

where M_{max} is the maximum value of the effective escapement area of O_2. The overall sensitivity of an instrument based on this principle will, of course, depend also on the sensitiveness of the device used for measuring p. This device should preferably be linear in terms of p and, in view of the requirement $0\cdot4<p/P<0\cdot9$, be fitted with means for suppressing the zero so that the zero of the scale corresponds to a pressure p equal to $0\cdot4\,P$. Within this range the indications of the instrument will then be linear in terms of A. It is, of course, necessary that P should be kept constant in order to maintain consistency of calibration.

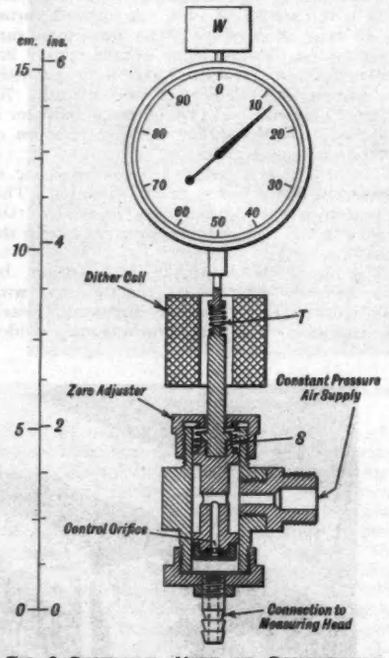


FIG. 2—SECTIONAL VIEW OF COMPARATOR

The speed of response of the instrument will depend on several factors, the chief of which are (1) the value of P, (2) the area C of the first orifice, and (3) the volume V between the two orifices; the response improves when P or C is increased or V diminished. It has been seen that for high sensitivity C should be kept small, so that, in the determination of the optimum size of O_1, high sensitivity and quick response are conflicting demands. With C determined by the sensitivity requirement, improved response must be sought by reducing V to a minimum and making P as large as is conveniently practicable.

DESCRIPTION OF INSTRUMENT

The instrument (Fig. 2) consists essentially of a hollow double piston which is an air-tight sliding fit inside a cylinder of ½in bore, the radial clearance being only about 0·0001in. Compressed air, maintained at constant pressure by a precision pressure regulator, is supplied to the centre of the cylinder, whence it flows downwards through the hollow piston to the control orifice. This orifice is simply a small hole drilled in a thin metal disc held in place on the bottom of the piston by means of a screw cap, an arrangement which enables the orifice to be changed easily when it is desired to alter the sensitivity of the instrument. After flowing through the control orifice the air passes to the lower part of the cylinder from which a connection is taken, by means of a short length of small-bore flexible tubing, to the measuring head. When the measurement to be made is the displacement of a surface, a simple jet—Fig. 3 (*a*)—may be used as the measuring head, the gap between jet and surface determining the effective escapement area for the air. The volume which determines the time constant of the instrument is that of the space in the cylinder below the piston plus the capacity of the flexible tube and measuring head. The total effective volume is, therefore, small and the speed of response correspondingly high.

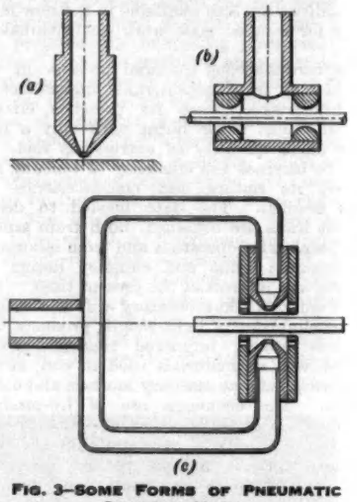


FIG. 3—SOME FORMS OF PNEUMATIC GAUGING HEADS

The piston is loaded by means of a compression spring S (Fig. 2). The initial compression of this spring is set by the "zero adjuster" screw so that, with a supply pressure of 15 lb per square inch, say, the piston just moves away from its lowest position when the pressure beneath the piston is 6 lb per square inch, i.e., $0\cdot4\,P$. Any further increase in the pressure p will produce a proportional upward movement of the piston. The effective escapement area at the measuring head is dependent on the air gap and experiment has shown that the movement of the piston is directly proportional to the displacement of the surface from the measuring jet within the limits set by the condition that p lies between 6 lb per square inch ($0\cdot4\,P$) and 13½ lb per square inch ($0\cdot9\,P$). By suitable choice of control orifice and compression spring in the cylinder, the ratio of movement of piston to displacement at the measuring jet may readily be made equal to 1000 : 1.

The movement of the piston is indicated on a 2in diameter dial gauge of ordinary pattern, the pointer of which makes one revolution for a spindle movement of 0·1in. The magnification provided by the dial gauge is, therefore, about 60 : 1, so that a total magnification of the order of 60,000 : 1 for the complete unit may be achieved. With this sensitivity, using a dial gauge having a scale of 100 divisions, each corresponding to a spindle movement of 0·001in,

* Communicated by the National Physical Laboratory.

one scale division would represent a relative displacement between measuring jet and surface of one millionth of an inch.

To overcome the effect of static friction between piston and cylinder, an extension rod of mild steel fitted to the top of the piston is arranged to project into a solenoid supplied with half-wave rectified alternating current. This produces a dither of the moving parts of small amplitude (about 0·001in) at mains frequency and completely eliminates the possibility of the piston sticking at any point in the cylinder. Half-wave rectification is used because the heating effect of the current in the coil, for a given maximum pull on the plunger, is thereby reduced by about 50 per cent, so that a smaller dither coil can be used than would otherwise be required. It is necessary to prevent transmission of excessive vibration to the dial gauge mechanism; this is achieved

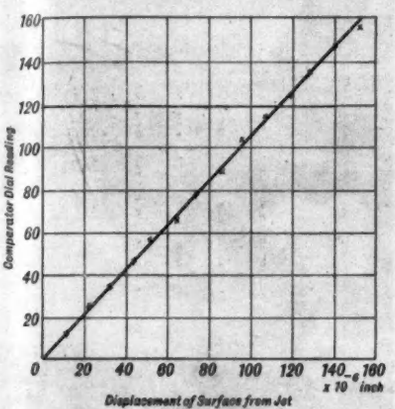


FIG. 4—COMPARATOR CALIBRATION

by a simple damping device consisting of a weight W (Fig. 2) fixed to the dial gauge spindle and a small compression spring T between this spindle and the top of the plunger.

CALIBRATION

The comparator has been calibrated in terms of light-waves by means of a displacement interferometer. For this purpose the instrument was fitted with the simple jet—Fig. 3 (*a*)—and was used to measure the displacement of the movable glass plate of the interferometer. The diameter of the jet was 0·040in, that of the control orifice 0·010in, and the pressure P was 10 lb per square inch.

The results of the calibration are shown in Fig. 4, in which the readings of the dial gauge are plotted against the displacement of the surface in relation to the jet, as measured by the interferometer. It will be seen that the calibration is linear over the range 0·00015in and that one division of the dial gauge represents 1×10^{-6}in approximately. The standard deviation of the results from the best straight line is 0·8 division.

FORCE EXERTED ON SURFACE UNDER MEASUREMENT

An approximate calculation of the force which is exerted in normal conditions of use by the jet of air impinging on the surface under measurement indicated a value of the order of ¼ oz weight. As the premises of this calculation were open to doubt, an experimental measurement of the force was made. It may be of interest to describe the method adopted since it employs a technique which might prove useful in other and, at first sight, somewhat unrelated applications.

Fig. 5 shows the apparatus. The jet J_1 to be tested is rigidly fixed at the appropriate distance beneath an aluminium disc A supported with its surface horizontal by three light springs. It is connected to the compressed air supply through a precision regulator so that the pressure at the jet, as indicated on the gauge, can be accurately set to the required value. The upward force exerted by the jet of air on A is determined by direct weighing, the aluminium disc B, which is suspended from A by three wires, serving as a scale pan, whilst the dashpot C provides sufficient damping to make the system aperiodic.

The comparator, in association with a jet J_2 fixed just above disc A, provides a criterion for judging when the correct weights have been added to the scale pan, the procedure being as follows. Commencing with no air supply to J_1, the position of J_2 in relation to A is so chosen as to give some convenient reading on the dial gauge of the comparator. The air supply to J_1 is then adjusted until the required pressure is attained and weights are added to B until the dial gauge reading is restored to its original value. Readings can be taken quickly and easily, so that a set of observations covering different pressures and different distances of J_1 from A can readily be obtained. As an example of the results obtained from these tests it may be quoted that the force on a surface due to a jet of air at a pressure of 10 lb per square inch from an orifice of diameter 0·040in at a distance of 0·001in from the surface is 0·2 oz (6 g) weight.

ALTERNATIVE FORMS OF MEASURING HEAD

Mention has been made of the use of a simple jet—Fig. 3 (*a*)—as a suitable measuring head for the direct measurement of the displacement of a surface. Fig. 3 (*b*) shows a sectional view of an alternative measuring head suitable for gauging the cross-sectional area of thread or wire. It is of box-like form with a shaped orifice in each of two opposite faces and is connected to the comparator by the tube entering the upper face. With properly dimensioned orifices "cross cornering" of the wire in the head has an inappreciable effect on the comparator reading.

A third form of measuring head for gauging thickness is illustrated in Fig. 3 (*c*). Two jets are connected in parallel so that the effective area of escapement M at the measuring head depends on the sum of the two escapement gaps formed between the jets and the material being measured. With this arrangement the reading of the comparator will, within certain limits, be independent of the location of the material between the jets since the sum of the two air gaps between jets and material will remain constant for a given thickness of material. The theoretical analysis briefly outlined above depends on the assumption that the coefficient of contraction for the air escaping at the measuring head remains reasonably constant. This will be the case unless

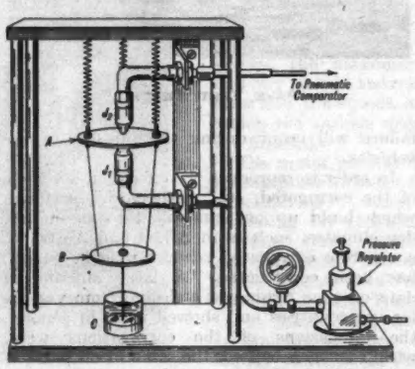


FIG. 5—MEASUREMENT OF FORCE EXERTED BY JET

the material is moved too close to one of the jets, when the coefficient of contraction for the air escaping from this jet may be reduced appreciably making the effective total escapement for the air at the measuring head less than before; the pneumatic gauge will then indicate an apparent increase in the thickness of the material. To obviate this, a guard ring is fixed around each jet, as shown in Fig. 3 (*c*), with the surface of the ring protruding slightly beyond that of the jet. If the material should touch the guard ring, air can still escape from the jet through holes drilled in the side of the measuring head as indicated in the diagram. The guard rings also provide mechanical protection for the jets.

EXAMPLE OF USE OF COMPARATOR

As an example of the use of the comparator for fine measurement, mention may be made of a determination at the Laboratory of the movement of the flapper of an industrial pneumatic amplifier of the type described in the authors' earlier paper.[1] This determination was made in order to establish the mode of action of the flapper mechanism. The comparator was used in association with the simple jet measuring head, which was fixed rigidly to the amplifier case so that the nose of the jet was at a mean distance of 0·0008in from the flapper. By varying the input to the amplifier in steps, a series of corresponding values of comparator reading and amplifier output was obtained. The results are given in Fig. 6,

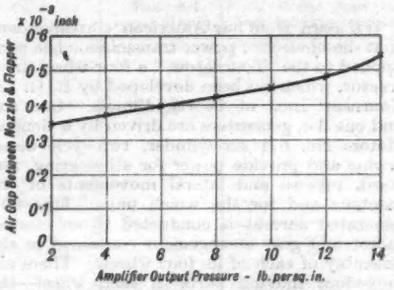


FIG. 6—MOVEMENT OF FLAPPER OF PNEUMATIC AMPLIFIER

which shows a plot of the distance of the flapper from the amplifier nozzle against amplifier output pressure. The total range of movement of the flapper corresponding to a change in output from the minimum value of 2 lb per square inch to the maximum of 14 lb per square inch is 0·0002in.

CONCLUSION

The comparator which has been described has the advantages of a simple and robust design so that it may be used in the workshops as well as in the inspection room. At its maximum sensitivity it may be used to measure displacements of the order of a few millionths of an inch; by changing the size of the control orifice, which can be done quickly and simply, the sensitivity can be reduced so as to provide for direct measurements of up to a few thousandths of an inch. As an approximate working rule, when it is required to measure displacements of a surface in the range x inch, the minimum gap between the measuring head and the surface will be $\frac{1}{4}x$ inch.

As the measuring head does not make actual contact with the surface under measurement, the comparator is particularly useful in certain applications. Thus it has been found that, with the caliper arrangement of jets as measuring head, accurate determinations can be made of variations in thickness of rubberised fabric during actual production and despite the stickiness of the surfaces. When necessary, the measuring head can be made very small in overall dimensions and since its connection to the comparator is by a thin flexible tube, it can be inserted into confined spaces which would be inaccessible to the commoner type of comparator with rigidly attached measuring head.

The speed of response is quite high so that even at maximum sensitivity readings may be taken almost immediately. There are no sources of hysteresis so that the comparator is completely free from this kind of error.

It is clear from what has been said that the instrument is a comparator and is unable to provide absolute measures. Calibration may be carried out in the usual manner, using slip gauges, but at the highest sensitivity it becomes necessary to use special slip gauges (e.g., differing in steps of 0·00002in) which have been accurately standardised. Since the reading of the comparator is dependent on the value of the working pressure (P), the pressure of

the air supplied to the precision regulator should be kept reasonably constant. To realise the precision quoted in the paper it was necessary to limit the range of variation of the supply pressure to 5 lb per square inch.

The work described in this article has been carried out as part of the research programme of the National Physical Laboratory, and the article is published by permission of the Director.

REFERENCES

[1] Evans, J. C., Graneek, M., and Lee, H. G., "Continuous Pneumatic Gauging of Material in Thread or Wire Form," "Trans.", Soc. Instrum. Tech., 1950, 2, No. 2, page 34.

[2] British Prov: Pat. No. 28,719/49, cog. 1471/50.

A Diesel-Electric Tractor

WE learn from our American correspondent that diesel-electric power transmission has been applied to the "Tournatow," a four-wheel drive tractor, which has been developed by R. G. Le-Tourneau Inc., of Peoria, Illinois. One a.c. and one d.c. generators are driven by a General Motors No. 671 six-cylinder, two-cycle diesel engine and provide power for all steering, forward, reverse and lateral movements of the machine and for the winch unit. This self-generated current is conducted to an electric motor and gear arrangement contained in the assembly of each of its four wheels. There are only four moving parts in each wheel—the pinion, two reduction gears and the internal gear within the wheel. The effectiveness of the drive system was shown when, in a recent demonstration conducted for the U.S. Air Force at Wright Field, the machine developed a pulling power sufficient to manœuvre aircraft weighing about 180 tons or more than sixteen times the weight of the "Tournatow." The operation of the machine is relatively simple. The throttle for its diesel engine is advanced to turn the generators at the required speed. Regulation of the flow of electric current from the generators to the wheels is accomplished through a potentiometer, whose action is similar to the speed and power controller used on trams. Advantages claimed for the machine are its ability to develop a smooth start, a smooth pull and quick and easy stops. A power stop can be accomplished simply by returning the controller to the "off" position. After the diesel engine is started and the throttle opened, no further use of the throttle is necessary. Steering, according to the makers, is accomplished in the simplest and easiest way—by the use of pushbuttons: forward and reverse movement by rotating the controller handle. The three-unit power assembly—engine, a.c. generator and d.c. generator—is held in position by four mounting bolts and can be removed with ease. Connection between the power plant and the motors is through flexible electric conductors. As the motors are placed at the points of application, all intermediate and final drive gears and shafts, transmissions, universal joints, the hydraulic braking system and other mechanical gearing and linkages are eliminated. Each drive wheel is suspended on ball and socket bearings. The tyres are 56-in standard aircraft units. The steering motors are situated at the front and rear of the tractor and are individually controlled from the cockpit by means of finger-tip switches. Limit switches automatically cut off the steering motors when the wheels have reached their limit of turn. The three-phase a.c. generator is mounted in line with the engine. A two-unit transformer group mounted on the a.c. generator, provides excitation current for the generator field and charges the batteries. Rectifiers convert the a.c. from the transformer secondary windings into the d.c. necessary for field excitation and battery-charging purposes. Automatic multiple disc motor brakes support the a.c. motor loads when the motors are not in operation. Brakes are applied by strong coil springs and are released by the pull of magnets energised when power is applied to the motor.

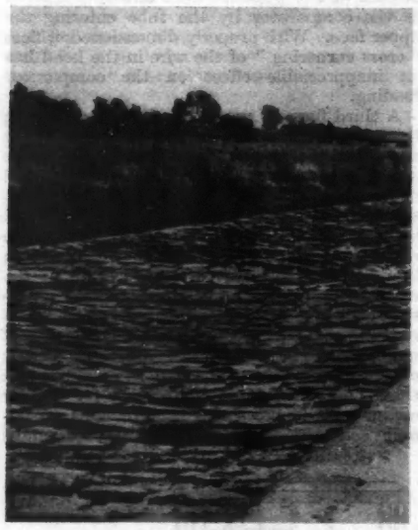
Automobile Proving Ground

RECENTLY we were invited by the Motor Industry Research Association to visit its proving ground at Lindley, near Nuneaton, where an Open Day had been arranged. This proving ground was opened two years ago and was formerly the disused Lindley airfield. Upon its main runways and taxi-strips have been laid the various test track surfaces, which, along with certain other facilities, are available to the motor industry for research, development and test purposes.

TEST TRACKS

A primary aim in the choice of road surfaces has been to simulate the exacting road condition experienced overseas. The Belgian *Pavé* test track is a road surface ½ mile in length, which has been laid to reproduce permanently a Belgian *pavé* road in a bad state of repair. The specification for its construction was drawn up on the basis of detailed measurements made on an actual main road in Belgium. The *pavé* track forms an excellent accelerated endurance or fatigue test on complete vehicles, and is illustrated below.

Manufacturers are now running individual vehicles over this track for several hundred miles to satisfy themselves that no major



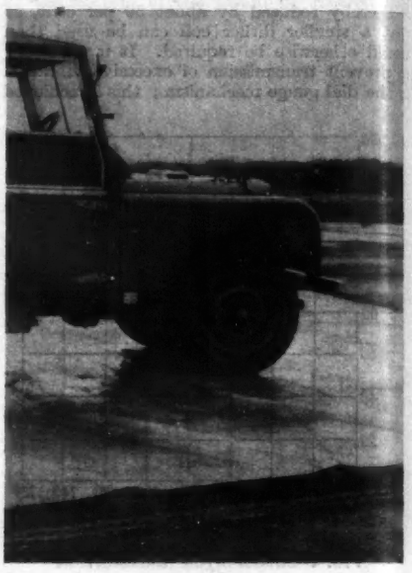
PAVE TEST TRACK

failure will occur during the lifetime of the vehicles.

In order to reproduce the effects on a vehicle of the corrugated, or "washboard," surfaces, which build up on unmetalled roads in hot, dry climates, such as in Africa and Australia, a concrete corrugated road, ½ mile in length, has been constructed. A large amount of data on such roads was collected from various foreign countries and showed that, in general, the dimensions of the corrugations were, within an inch or two, the same in all parts of the world. In the reproduction road, the crests of the corrugations are about 30in pitch and 1in high. Over 11ft of the width of the road the corrugations are at right angles to the direction of travel, and they are inclined at 21 deg. over the remaining 5ft width. This last provision has been made so that a vehicle can be driven with, say, a nearside wheel on a crest while the offside wheel is in a trough, or in any intermediate position depending on the lateral position of the vehicle on the track.

A shallow water splash, up to 3in deep, is filled from a 7000-gallon storage tank. It is used mainly for testing the weatherproofing of vehicles when driven through it at about 30 m.p.h.

There is a dust tunnel which is an experimental of reproducing the dusty road conditions encountered in undeveloped and tropical countries. Nissen hut sections placed end to end provide a tunnel 200ft long and of sufficient section for vehicles up to the size of a single-deck bus to be driven through at speed. On the floor of the tunnel are placed varying quantities of a specially selected dust. Illuminated guide



CORRUGATED TRACK

rails are fitted for added safety in dense dust conditions.

Another track illustrated overleaf has been designed to generate high levels of road noise in vehicles. Several kinds were tested before the "saw tooth" and "lumpy" surfaces were laid. A stretch of super-smooth asphalt is used as a reference surface producing the lowest possible noise level.

TIMING STRAIGHTS

Towards each end of the main 2000 yards long runway a timing section has been provided. The sections are so arranged that a vehicle can be accelerated over almost 1600 yards, timed with an "Airmec" electronic counter over either or both of two adjacent 50ft lengths, and braked over the remaining 400 yards. Two timing straights are provided, side by side, to allow runs to be made in opposite directions. A vehicle entering and leaving each 50ft timing length breaks a light beam falling on a photo-electric cell, and the electrical impulses so set up start and stop the electronic counter, which is accommodated in a hut halfway along the straight. This equipment measures the time taken to travel 50ft in increments of 0·00001 sec and is accurate to within 0·2 per cent.

A flat concrete circle of 250ft diameter is provided where a vehicle can be driven at various steering angles and at selected speeds. A centre post is used to sight measurements of roll and altitude angles. From these and other measurements made on the vehicle itself a detailed study can be made of the stability characteristics of the vehicle such as under-steer or over-steer at different lateral accelerations.

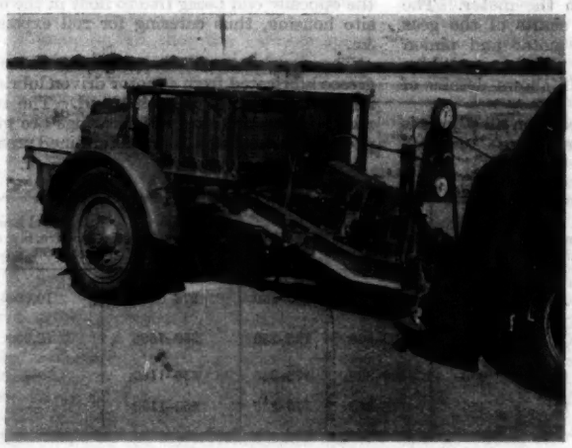
To compensate for the absence of hills on the M.I.R.A. proving ground, an absorption dynamometer trailer (shown on page 65) has been designed and built by the Association for imposing easily adjustable loads and speeds on towing vehicles. The energy is absorbed electrically and power absorption is of the order of 60 h.p. throughout the speed

range. The trailer is capable of imposing a maximum retarding pull of over 2000 lb at 4 m.p.h., declining with increase in speed to a maximum of 500 lb at 45 m.p.h. A strain gauge dynamometer, which indicates the retarding pull imposed on the towing vehicle, is included in the drawbar arrangement.

There was also an exhibition of test instruments developed by the M.I.R.A., amongst

NOISE GENERATING TRACK

which were two unbonded wire resistance accelerometers, one being designed to measure accelerations of 5 g with a natural frequency when damped of 355 c/s. Wire prestressed is looped around two sets of bobbins between which is placed the mass. The other accelerometer has



POWER ABSORBING TRAILER

a range of 1 g. with a damped natural frequency of 140 c/s.

During the day, racing and test track drivers were on hand to enable visitors to experience the actual track conditions in cars provided by the various manufacturers.

CONFERENCE ON ROLLING MILL DESIGN.—It is very much regretted that, in the specially contributed report of B.I.S.R.A.'s June conference on the above subject, appearing in our issues of June 29th and July 6th, Mr. J. F. R. Jones, of John Summers and Sons, Ltd., was incorrectly described as "consulting rolling mill engineer." Mr. Jones is, in fact, Chief Engineer, Construction and Development, of the firm.

Rolling Mill Design*

No. III—(*Continued from page 28, July 6th*)

ROD AND BAR MILL AT GUEST, KEEN AND NETTLEFOLDS (SOUTH WALES) LTD., CARDIFF†

THIS mill, which has been running only for about nine months, has been designed specifically for production of rods and bars for cold headed products. It is the fastest of its kind in this country, probably in the world. It consists of an eleven-stand roughing train, two-stand intermediate train, four-stand looping train and a six-stand rod finishing train. Seventeen main mill motors are incorporated in this mill, and up to stand 16, fifteen stands are of individual drive, and only two stands, i.e., 0–1, are driven by one motor. The rod finishing train has six stands for the small sizes produced, and is driven by a single motor. The range of sizes covered in the mill is from 5 gauge up to 1in diameter and the rate of production, starting at 5 gauge, is 27 tons per hour, and goes up to 60/70 tons per hour when rolling 1in, but to date, it has not been possible, due to steel shortages, &c., to operate on the larger sizes.

Table I shows the maximum roll diameter, motor sizes, powers and speeds, the maximum delivery speeds, the roll sizes and the stands in which the various sizes are finished.

The motor generator set comprises a 4750kVA synchronous motor, operating on 11,000V, driving three 500V d.c. generators, one of 2000kW and two of 1500kW capacity. These three generators can be coupled together to supply power to all the mill, or, alternatively, one generator can supply current to the roughing and intermediate trains, one to the looping train, while the remaining generator supplies the motor of the rod finishing train.

The housings of the roughing mill are conventional, with normal screw adjustment of the top roll. The bearings are of the fluid film type, with the top roll spring balanced. Provision is made for bottom roll adjustment and this is of the screw wedge type, with individual adjustment to each bottom chock. Longitudinal adjustment is obtained on the bottom roll only, through a system of levers and screw adjustment. The same sort of housings are used for the intermediate mill, and also for the looping train. In the latter housings, however, provision is made to traverse each set in the longitudinal direction of the barrel in order to align the passes in use with the repeaters or guide troughs to the repeaters. This is done by means of a hydraulic cylinder operating on each roll housing.

The double strand up and down cut shear is driven through gearing from the main mill motor driving stands 0–1, and is actuated by means of a solenoid which sets in motion the mechanism to give one revolution of the shear and cut out. The shear is overhung, and is actuated by two eccentrics on a common shaft with the centre eccentric operating the top blades and the two side eccentrics operating the bottom blades. The shear is controlled by three push buttons, whereby it is possible to cut on both lines or either one of the two lines. Each top blade is pivoted, and can be moved and made inoperative by means of an air cylinder, so that it is possible to cut on one line only. During the period of cutting, the whole shear moves forward with the passage of the billets, when the billet is in the mill or, alternatively, remains stationary when cutting off the front end of a billet. In order to line up the shear with the passes in use in the mill, the whole shear is moved by means of a hydraulic cylinder, and to allow for this movement in the driving end of the shear, a splined shaft is provided whereby the shaft moves and the gear wheel driving the shaft remains stationary.

To avoid scratching of the rods and bars, roller twist guides have been developed. For the same reason, the repeaters of the looping mill are all provided with rollers mounted in the bulkhead. The rollers are mounted on ball and roller bearings and rotate freely when the stock comes in contact with them.

When rolling sizes from 5 gauge up to $\frac{1}{16}$in diameter, it is essential to crop the front end of the stock prior to entering the intermediate and succeeding stands. An electronically-controlled and completely automatic shear is used. It has four circular blades mounted in pairs, one above the other. The bottom pair cuts the front end and the second pair is only used when a cobble occurs in the intermediate stand. Then it is possible to cut with the top set of blades and divert the material to scrap.

There are four laying reels used for sizes up to $\frac{3}{8}$in in diameter. All are driven by one 50 h.p. motor at 600 to 1720 r.p.m. through four gearboxes, each with a clutch to enable any reel to be put out of operation. From these gearboxes, a spindle drives to the reel proper, and here, a further set of bevel gears is used for driving the shuttle which lays the rod between the reel pins. For stripping the reel, a 7½ h.p motor lowers the reel pins, after which a

TABLE I

Stand No.	Roll dia. in.	Motor h.p.	Motor r.p.m.	Max. del. speed, ft/min	Rolled Sizes and finishing stands
0–1	16 $\frac{4}{16}$	200/200/130	900/300/195	—	—
2	,,	,,	,,	—	—
3	,,	300/300/195	,,	—	—
4	14 $\frac{12}{16}$	,,	,,	—	—
5	,,	,,	,,	—	—
6	13 $\frac{1}{2}$	,,	,,	—	—
7	,,	350/350/227·5	,,	—	—
8	,,	,,	,,	—	—
9	,,	,,	,,	—	—
10	,,	,,	,,	—	—
11	,,	,,	600/200/130	—	—
12	,,	,,	,,	—	—
13	11 $\frac{1}{2}$	,,	,,	—	—
14	,,	,,	750/250/162·5	—	—
15	,,	,,	,,	—	—
16	,,	,,	,,	2150	4/0 to 1in dia.
17	10 $\frac{61}{64}$			1740	$\frac{3}{8}$in 3/OG. 2/OG.
18	10 $\frac{1}{2}$				
19	10 $\frac{45}{64}$	1750/1750/1138	835/600/390	—	—
20	10 $\frac{25}{64}$			3750	1G. $\frac{4}{16}$in 1/0.G.
21	10 $\frac{53}{64}$			—	—
22	10 $\frac{29}{32}$			5100	5G. 4G. 3G. 2G. 0·286in

* Conference, June 13th and 14th. Plant Engineering Division of B.I.S.R.A.

† Paper by G. A. Phipps.

further 7½ h.p. motor actuates the push-out mechanism, which ejects the coil onto the conveyor. For sizes larger than ¾in, which are finished at stand 16, pipes leading from this stand deliver the bars to one of four pouring reels. These reels are each driven by 50 h.p. motors running at 520 to 1040 r.p.m., and for stripping and pushing the coil onto the conveyor again, two 7½ h.p. motors are used. While it might appear that a 50 h.p. motor is large for this duty, it should be noted that it is required for acceleration and deceleration only as, when the motor is running at speed, the current taken is very low. With this kind of mill it is essential, in order to get maximum production, that the reels should be able to accelerate and decelerate in a matter of a few seconds.

There are six separate oil systems in the lubrication cellar supplying drives and bearings of the mill, each system with a main storage reservoir electrically heated and thermostatically controlled, from which the oil is pumped through a self-cleaning filter and cooler to the Morgoil bearing or meshing points of drives, returning by gravity flow to the reservoir. Each system has two supply pumps, one normally operating, the other cutting in automatically should pressure drop. Riding on the supply line is a pressure tank controlling the pressure switches which operate the pumps, warning sirens, signals, &c., and carrying an emergency supply of oil sufficient to clear the mill if total stoppage of pumps, due to power failure, should occur.

The mill has only been in operation nine months, but due to the steel position and the demand for rods, it has only been possible to operate the mill continuously on sizes from 5 gauge to ¾in. To date, on 5 gauge and 4 gauge, during a 17-shift week, 3150 tons has been obtained, and the best shift to date on 5 gauge rods is 219 tons in a 7½ hour working shift.

Discussion

During discussion on this paper, the suitability of continuous mills for rolling alloy steels was touched on. Both Mr. George, who said that in many respects Consett's bar mill at Jarrow was similar to the mill described, and Mr. Phipps had rolled alloy steels and thought that with sufficient care in setting up undue difficulty should not be encountered. Mr. N. D. Thomson, however, commented that although continuous mills were now being used more and more for alloy steels, difficulties could arise when they were used for, say, stainless strip, when pulling between stands caused surface defects to open up at the cold rolled stage.

Replying to several speakers who asked about tolerances, Mr. Phipps said that on the Castle Works bar mill they had rolled 100 tons in coils within 0·005in, where the tolerance allowed was 0·010in (1·110/1·120).

He regretted that it would be another six months before they would have satisfactory comparisons between this mill and previous mills on the sizes rolled. He was convinced that there would be no difficulty in maintaining the required accuracy.

Roller guides, pass life and the oval/round roll pass design, and the angular cut given by the disc shear were all commented on. Of roller guides, Mr. Phipps said that theirs were changed three times per week, which was far less than when the original guides had been tried. He thought that there was a big future for this system. The rolls were made of 0·4 carbon with stellite in a groove $\frac{1}{16}$in deep. The speed of the roller guides was 9000 r.p.m., and the "piece" was in contact with the rollers the whole time. On pass life, they normally rolled a whole shift; they could hold gauge up to five hours compared with two-and-a-half hours on the old mill. He was convinced that oval/round design led to less wear on passes than oval/square.

The angular cut given by the disc shear resulted in an easier entry into the rolls.

The Light Section Mill, the Darlington and Simpson Rolling Mill Company, Ltd.‡

The light section mill was installed at Darlington at the end of December, 1946. It is the conventional cross country type, and is arranged to give a great degree of flexibility in the method of rolling, and the design of the commodity produced. Whilst the bulk tonnage produced consists mainly of standard metal window sections, some twenty-four special shapes for other industries are also produced. Since precision rolling at high speed was sought, the criterion in the design of the mill was low rolling tolerances and surface finish.

The scheduled output was 75 tons per shift or 60,000 tons per annum, and this figure has been exceeded on a wide range of the products rolled. The weight of the sections produced is just over 1 lb per foot and a high standard of accuracy has been achieved in the products rolled.

Each set of mill stands except the final finishing stand, is driven from the motor through a totally-enclosed pressure lubricated double helical gear reduction set. The final finishing stand is driven direct from the motor. The high speed and low speed shafts of the gear sets are connected to the motor and pinion housing respectively by Wellman Bibby flexible couplings. Table II shows details of the various mills.

The adjusting of the top rolls on all stands is through a hand lever operating a "castle" nut, which in turn operates the main screw. The operating lever is held in position by the usual pegged quadrant plate fixed to the housing.

The roughing mill top tolls are suspended from the open top housing cap by spring loaded suspension bolts attached to a roll neck carrier chock. The bottom roll is adjusted by a screw-up gear operated by a hand ratchet operating a vertical shaft revolving in bearings attached to the housing. To the opposite end of the shaft is fitted a pinion operating a gear wheel screwed to receive the chock screws. The gears are totally enclosed in a cast iron gear case, as a protection against scale and, with the screw, are grease gun lubricated. The bottom rolls of the intermediate and finishing mills are adjusted by horizontal wedges and screws.

The bars are manually fed into the various passes. For certain sections both stands are fitted with repeaters bolted on the first roughing stand to the cramp, and on the second roughing stand on both sides of the housings.

When repeating in the first stand, overhead repeating is resorted to, but in the second stand repeating is done from bottom to top on one side and from top to bottom on the other side.

The roughing mill bearings consist of cast steel water-cooled chocks, lined with white metal. The intermediate and finishing mill bearings are carried in cast steel chocks fitted with "Skefko" roller bearings and with accurate means of adjustment. In view of the need for accurate rolling, the chocks fit neatly into closed top type mill housings. The roll chocks are fixed positively at one end of the mill housing only, the opposite end being free to float in the opposite housing, thus catering for roll expansion, &c.

The roughing mill bearings are force fed grease lubricated from a motor driven lubricator mounted adjacent to each stand. The intermediate and finishing mill bearings are grease packed on assembly to a predetermined pressure, and during rolling operations additional grease is added by a high pressure grease gun through a grease nipple located near the wobbler end of the roll. As the roll neck is drilled and plugged at the end, grease can thus be fed to a small annular groove on the roll neck situated in the centre of each bearing race.

Complete sets of roller bearings are carried, which take turn about with those in the mill, in this way each bearing is rested and it is hoped it will be found to lengthen their life. In addition, it provides the opportunity for the bearings to be rigidly inspected and properly maintained from time to time, and reduces the chance of sudden and unexpected failure. The wear which takes place in properly lubricated bearings is negligible, and this enables the

Fig. 4—Roughing Mill Showing Repeaters

Table II—*Mill Data*

Mill Stands	Roll Barrel Length in	Drive h.p.	Motor Speed r.p.m.	Mill Speed r.p.m.	Delivery Speed ft per min.	Flywheel Energy Storage, h.p. secs at 800 r.p.m.
Roughing Mill: Two 16in, three-high	42	750	400–800	65–130	275–550	10,000
Intermediate Mill: Two 12½in, three-high	30	600	400–800	125–250	390–780	12,000
One 12½in, two-high	30					
First Finishing Mill: One 12½in, two-high	18	600	400–800	175–350	550–1100	—
Second Finishing Mill: One 12½in, two-high	18	450	175–350	175–350	550–1100	—

‡ Paper by W. French.

distance between the rolls to be maintained constant.

Tilting tables are fitted to the delivery side of both roughing stands. The tables are electrically operated from a master controller in the mill pulpit, and facilities are provided to alter the height of the table in operating to suit varying roll diameters.

To handle mill scale, concrete ducts have been constructed beneath the roughing mill approach tables, the roughing and mill trains, with sufficient slope to enable the scale to be flushed with water into a central scale pit. This pit, located in the billet yard, is constructed with three weirs, to settle out the scale before the water returns to the pump suction pit for recirculation. The accumulation of scale is regularly taken out by means of a grab fitted to the overhead crane.

Small electrically driven shears are provided at various places to enable any waste bars to be cut in lengths suitable for ease of transference.

A 450-ton Scriven shear is located in the billet yard on a concrete plinth at furnace level to shear the raw material into suitable lengths for charging into the furnace to give a predetermined finished length on the cooling bank.

It is capable of cutting one 3½in billet or three 2in billets at each cut. The frame of the machine is fabricated.

Powered by a 60 h.p. motor, the shears are operated by push-button and foot-pedal control, and the outgoing table is depressed as the bars are cut to assist in the operation.

Discussion

In discussion, it seemed to be generally agreed that the roller bearings on the mills played an important part in achieving the necessary straightness and accuracy of product.

Mr. T. W. Hood raised the point whether the extra cost of a variable speed motor on the roughing stand had justified itself for what appeared to be a standardised roughing sequence in view of the fact that fixed speed motors were used on the roller tables. And why were two motors used on the last two stands? Was it to obtain a higher finishing speed or to avoid backlash, end thrust, &c., between stands which were coupled together, and thus to increase accuracy? How many bars were there in the intermediate train at once?

Mr. French replied that the variable speed motor was used on the roughing rolls, as on some sections they were used as forming rolls from the section pass onwards, which gave them some awkward bites. Two motors were used on the last two stands solely because of speed variation, although one of them was so placed as to enable the intermediate train to be coupled up if necessary. They often rolled with a bar in every pass in the intermediate train and one day rolled 336 bars in one hour, that is to say, with a two or three second interval between the back of one bar and the front of the next.

A speaker asked if the capital cost of spare roller bearings was justified, and Mr. P. M. Miln said that the bearings presumably had a parallel bore with sufficient clearance for the chocks to be stripped. Had any trouble been experienced with fretting of roll necks due to the creep of the bore? Tapered internal race bearings fitted by oil injection method might be an answer if this problem arose.

Mr. French answered that compared with the cost of the mill, the capital cost of the spare bearings was negligible and had been money well spent. They had never had any trouble with parallelism of roll necks because they were all checked when they came from the makers.

Fretting was kept in check by grease fed through the roll neck to the inside race of the roller bearings; he was a believer in greasing little and often and it was applied during meal breaks.

Mr. W. M. Hadden (Dorman, Long and Co., Ltd.), said that there had been phenomenally little wear on the pads since 1946. What special precautions had been taken? Mr. French said that they were greased on installation and through grooves during meal breaks.

Mr. Stewartson asked for an accurate figure of cobbles occurring on the three-high repeaters fitted in the roughing train. He also raised the question of forming this type of section out of cold rolled strip of high surface finish. Were special precautions taken in the roughing stand for scale breaking to secure good surface finish competitive with such a product? Mr. French replied that their experience was that they get very few cobbles after settling down to roll. He quoted that recently 12 out of 16 shifts in a week had rolled more than 100 tons and the others had followed closely behind.

Compared with a cold-formed section, the rolled section was stronger and could have sharper corners, and was generally thought preferable. Water sprays were used on the rolls of the roughing stand for scale removal, and the repeaters also acted as scale breakers. He could say definitely that with this arrangement and improved heating of the billet, they were getting a better product than from the older mills.

Mr. Stewartson questioned whether the square corners of the rolled section were necessarily an advantage, as they would be more susceptible to corrosion than the radiused corner of a cold formed section.

General Discussion

Many of the subjects mentioned during the general discussion, which occupied the third session of the conference, have been introduced, for convenience, in the above summaries. But there were also several contributions on the subject of mill-manning and presetting. Mr. W. Craig thought that three men in control of a primary mill was perhaps excessive and might be cut down by a system of presetting. Mr Stewartson agreed, but pointed out that some wartime presetting installations were not now in use.

Mr. Udall said that he had seen in Sweden a preselector used on a mill rolling exclusively ball bearing steel, in blooms of only two sizes. In these straightforward circumstances the mill could be operated by only one man who controlled all operations by means of two joysticks.

Mr. F. B. George stated that a presetting system on a slabbing mill was used by the Steel Company of Canada, who reported that it was satisfactory. His firm was investigating the possibility of using some such system. He thought that some of those which Mr. Stewartson had referred to as having gone out of use were not used because of the lack of runs of the same size of material. At Consett they might be able to use it for uniform blooms 9in square, though for the different sizes needed for plates hand control was probably better. He hoped that they would bring their number of operators down to two, and they had explored the possibility of joystick control, but had not met with very great enthusiasm on the part of the mill designers.

Mr. T. W. Hood considered that three men were fully occupied in driving a modern blooming mill, and questioned the wisdom of attempting to reduce the number to two, with the attendant increased strain on the men. (Mr. George strongly disagreed on this point). There should be differentiation between two systems of presetting screw-down. In the first, the entire pass schedule was set before the arrival of the ingot, and the roller merely pressed a button before each pass to obtain the predetermined roll setting. In the second, as used in Canada, the roller set, for example, the fifth pass on a large dial, whilst the ingot was receiving the fourth pass. As soon as the ingot left the rolls, he pressed a button to operate the screw-down. The latter system left the roller with full control of the drafting to meet the requirements of different ingots.

On the general subject of mill design, it was widely agreed that the closest possible collaboration between mill designer and user was desirable from the earliest stage. Mechanical engineering failures do not, it would seem, play a major part in the troubles of rolling mill engineers, several of whom paid tribute to the reliability and design of their mills. Mr. H. E. Colley (Guest, Keen and Nettlefolds (South Wales) Ltd.), for example, stated that in his works the average mechanical stoppages in a similar rod mill built in 1935, was still about two minutes per shift, and the electrical stoppages a matter of seconds per shift.

The increasing accuracy of design, too, was commented on. Mr. W. Bailey paid tribute to the new degree of accuracy in rolling mill calculation made possible by researches on this subject by B.I.S.R.A., and Mr. N. D. Thomson endorsed the value of rolling mill load tests in which he had been interested for some time. These results might enable builders to reduce weights and powers, while a permanent roll load device raised the possibility of drafting up to the limit of the mill at each pass.

The British Coal Utilisation Research Association

The annual report of the British Coal Utilisation Research Association has been circulated this week, its principal contents including an account of the progress made during 1950 with the researches now in hand. The Association, which has now completed its thirteenth year, has three main research divisions dealing with domestic and industrial coal research and with laboratory research, the work of the divisions being directed by Mr. J. S. Hales, Dr. E. G. Ritchie and Mr. R. L. Brown respectively. The present research programme, the report says, has been designed with a view to securing the earliest and greatest possible progress towards solution of the most urgent problems of coal utilisation. In the domestic division last year, investigations were concentrated mainly on achieving smokeless burning in both open and closed appliances, and on water heating methods. In the industrial division, the furnace department has had in hand the problem of designing a cyclone combustion chamber for a coal-fired gas turbine. The report records that trials were continued last year with an experimental unit designed and erected at the Association's research station at Leatherhead. An important objective in this investigation is to utilise low-grade fines —of which there is an increasing supply—in such a way that as much of the coal-ash as possible drains from the combustion unit in the form of slag instead of becoming gas-borne. A considerable proportion of the Association's resources is being devoted, of course, to researches on immediate problems such as steam raising, the burning and gasification of low-grade fines and the efficiency of gas producers. But, as the report points out, a great deal of attention is also being given in the laboratory research division to fundamental studies of the mechanism of combustion, the formation of smoke, the physics and mechanics of solids and particles, and the chemistry and physics of the coal substance.

Canadian Engineering News

(From our Canadian Correspondent)

Diesel Engine Order

An order for twenty-four diesel-electric switching locomotives has been placed by the Canadian National Railways. The units will cost approximately 2,500,000 dollars. Twelve of the diesels, of 800 h.p., are to be built by General Motors Diesel, Ltd., at London, Ontario. The others, of 660 h.p., have been ordered from Montreal Locomotive Works. The 660 h.p. locomotives are for industrial service where relatively light tractive power is required. The new order will bring the roster of diesels on the Canadian National to 289 units.

Booster Units

Two booster units for increasing the capacity of diesel switching locomotives have been designed and manufactured by Montreal Locomotive Works and are now in service in the Canadian Pacific Railway's new St. Luc hump retarder freight terminal near Montreal. When connected to a diesel locomotive the new booster unit forms a team, which actually

does the work of two 1000 h.p. diesels, at low switching speeds, by doubling the starting tractive effort of the locomotive. The booster receives its power from the diesel engine of the switcher to which it is attached and has no cab, separate controls or engine, making it less expensive to build and operate than a diesel unit. The principle of the booster's design originates from the ability of diesel-electric locomotives to deliver an extremely high tractive effort at the wheel-rim, enabling them to start long strings of loaded freight cars. When connected to a booster unit, a diesel locomotive can transmit the same high tractive effort to the eight additional wheel-rims of the booster. The new unit is built on the frame of a standard 1000 h.p. "switcher," and contains a compartment housing the reverser and other electrical equipment, the traction motor blowers and three ballast compartments containing approximately 52,000 lb of steel and poured concrete.

Steel Mill Expansion

A site is being prepared for a 600,000-dollar addition to the north plant of Atlas Steels, Ltd., at Welland, Ontario, to accommodate machinery for a cold reduction mill to expand the company's ability to supply a wider range of sheet products. This company is the major producer of tool and specialty steels in Canada, and it is claimed to be the largest tool steel company in the British Empire, supplying Canada and more than fifty-eight other countries. Using the electric arc process, the company manufactures high-quality alloy steels and tool steels of all types in a variety of shapes and sizes used in nearly all classes of industrial manufacture throughout Canada.

Aluminum Plans

The Quebec Government has authorised the Aluminum Company of Canada to go ahead with plans for a hydro-electric development on the Peribonka River, in the Lake St. John district, at an initial cost of 30,000,000 dollars. The first stage of the development on the Peribonka will be at Chute Du Diable and further development at Chute Savanne will cost millions more. The existing international situation has given impetus to the power projects since an increasing demand for aluminum has developed in world markets, and particularly in the United States.

Modernisation Programme

An 11,000,000-dollar modernisation and expansion plan covering the next three years has been announced by the Powell River Pulp and Paper Company. Improved facilities will increase production of newsprint by 40,000 tons a year. The plant now produces 1000 tons a day. Contracts totalling 2,000,000 dollars have already been let for work on the wharf, sawmill and acid plant. Powell River is 75 miles upcoast from Vancouver.

Continental Engineering News

(From our Continental Correspondent)

The Mezzo Bridge Over the Arno at Pisa (Italy)

An interesting bridge, recently completed at Pisa, is the Mezzo Bridge, over the River Arno. It is a concrete structure with a rigid reinforcement composed of rolled steel sections. The theoretical length between centres of abutments amounts to 251ft, the width of the bridge being 49ft. The bridge is of four-cell box-section, consisting of upper and lower slabs connected by two inner and two outer longitudinal diaphragms. The intrados of the superstructure is parabolic, while the extrados is practically rectilineal. Abutments are founded on 120 concrete piles of the Considere type, having a cross section of 16in by 16in, with lengths ranging from 53ft to 59ft.

The contract was carried out by the S.A. Ferrobeton, which used a steel girder of the Melan lattice truss type. This girder, weighing some 106 tons, acted both as centring and reinforcement. In the case of the Mezzo Bridge the novelty of the process lies in giving up the usual practice according to which the centring is preloaded with ballast, whose distribution and weight equal the final concrete caste. During the concreting the ballast is removed and consequently the stresses in the truss elements remain unaltered. The builders of the Mezzo Bridge considered, however, that because of the creep of concrete, fresh concrete flows over the centring. Taking into account the static contribution of concrete, notable advantages are obtained.

A Motor Road Between Belgrade and Zagreb (Yugoslavia)

A new motor road between the Yugoslav capital and the city of Zagreb, a distance of some 200 miles, was recently opened. The width of the highway is at present 39½ft, 24½ft of which is for motor traffic. It is expected to increase this width, in the future, up to a total of 82ft. The motorway will then include two carriageways, each 29½ft wide, with a central reservation 13ft wide. The carriageways are generally of concrete construction, consisting of concrete slabs, 7½in thick; some sections, however, are of tarmacadam. The construction of the new motorway involved the erection of many engineering structures, including eleven overbridges, and seventy-five reinforced concrete bridges, totalling some 5800ft in length.

New Building of the Belgian National Bank, Brussels

An important building, which will house the services of the Belgian National Bank, was recently completed at Brussels. This structure has been erected on the line of the railway tunnelling works of the North-South junction railway scheme. It measures 656ft by 52ft and is founded on the tunnel itself, from which it is insulated acoustically by means of precompressed mattresses of sheet lead and asbestos. The North and South circular halls of the building are founded partly on undisturbed ground and partly on the tunnel and there is a subway under the tunnel. The subway is 10ft below the water table and is kept dry by means of a copper sheet lining. The building is of pleasant appearance and was designed by M. Van Goethem (architects) and Messrs. Verdeyen and Moenaert (consulting engineers).

Jubilee of a Belgian Civil Engineering Firm

The Compagnie Internationale des Pieux Franki celebrated at Liege, in April, the fortieth anniversary of its foundation. Established with the main object of exploiting the patents of Monsieur E. Frankignoul for making *in situ* concrete piles, the company has spread all over the world. In addition to its piling activities, it has carried out important public works in various countries. The Belgian branch is responsible for the construction of two tunnels (for motor and pedestrian traffic) driven under the Scheldt River in Antwerp as well as for works on the Albert Canal. Recently the Franki Company was entrusted with the construction of a second lock at Kruisschans, at the Port of Antwerp.

Power Production in Switzerland

The Swiss Federal Office of Electric Economy recently published interesting data dealing with the production and consumption of electrical energy in Switzerland. According to this report, the annual production during the period October, 1949 to September, 1950, amounted to 10,479 million kWh (including energy supplied by thermal power stations) as compared with 9745 million kWh produced during the previous year. In 1949–50 electricity supply companies generated 79·2 per cent of the total, the rest being produced by the railways and industrial companies. Swiss power stations exported some 140 million kWh but about 258 million kWh were imported from abroad. By October 1, 1950, numerous power stations were either under construction or being enlarged. When the extensive constructional work now in progress is completed, which is expected to be by the winter of 1955–56, the country will be in a very satisfactory position, and even if weather conditions are extremely unfavourable it is expected that all demands for electricity will be met.

Development of Highways in Turkey

Public works are at present being carried out in Turkey to improve the highway network of that country. Although the overall length of Turkish highways amounts to some 27,000 miles, there is no continuous system of roads and many roads are narrow and sharply curved. A committee appointed by the Government prepared a highway scheme, after a careful study of the problem in Europe and the U.S.A. and the programme is now being carried out by the General Directorate of Highways of the Turkish Ministry of Public Works. The construction of the highways also involves the building of many new bridges and it is estimated that some 25,000ft of new bridges will be required. They will be constructed either in masonry or concrete by local labour or in steel prefabricated units, imported from abroad.

The Water Supply of Vienna

The water supply system of the city of Vienna has two principal aqueducts, which bring water from springs situated in the high mountains, some distance to the south of the city. The supply is variable in quantity, and in order to store the periodic excess of water, it has been decided to build a new reservoir supplied by the first aqueduct, which will have a capacity of about 18½ million cubic feet (the aqueduct itself was improved some years ago). The reservoir will be built in the Steinfeld area, south of Vienna. It will be a covered reservoir and will be built of reinforced concrete consisting of four independent chambers, each about 450ft by 390ft, with a depth of about 28ft. The roof will be supported by pillars at 30ft intervals. The reservoir will be completed in five years, it is estimated, at a cost of some 55 million Austrian schillings (£800,000).

The Dobrudja Canal, Rumania

Construction of the Dobrudja Canal, in Rumania, was started about two years ago, and is expected to be complete in 1955. The canal is about 63 miles long; it will start at Cerna Voda and then pass near the borough of Medjidia, forming a curve to the north, and then joining the Black Sea at the Midia Cape, north of Constanza. The canal will shorten considerably journeys up the Danube, and will greatly improve Rumanian inland navigation. A system of railways and highways will be built along the canal, as well as other developments, including two new towns. When all the works are completed, the Midia harbour will be the most important Rumanian port. In addition to the works referred to above, the scheme includes important irrigation works intended to improve the agricultural conditions in the Dobrudja country, one of the poorest areas of Rumania.

Restoration of the Edertal Dam, Germany

The German technical press has recently given some interesting details of the restoration of the Edertal dam on the Upper Eder, which suffered heavy damage from an R.A.F. raid during the war. The dam, which retains some 260 million cubic yards of water, is 154ft high. Its thickness varies from 118ft at the base to 13ft at the crest. Two power stations were built at the foot of the dam, one on each bank of the Eder. The 4-ton bombs used by the R.A.F. opened a gap in the dam with a width of nearly 200ft. About 80 per cent of the impounded water was lost, and some 15,000 cubic yards of masonry were torn away by the explosion. The gap has now been closed with masonry, and the upstream face made watertight. Drainage pipes have been incorporated around the gap, and cement has been injected under pressure through some 1400 holes, each 26ft deep and 2½in in diameter. Some 150 tons of cement were used for this work. Although restoration works have been complete for some time, the dam is still kept under observation and subjected to various tests and measurements to check its soundness and water-tightness.

Industrial and Labour Notes

The Economic Situation

The Chancellor of the Exchequer, Mr. Gaitskell, stated in Parliament on Wednesday of last week that, during the second quarter of this year, the gold and dollar surplus of the sterling area amounted to 54,000,000 dollars, compared with a surplus of 360,000,000 dollars in the first quarter, and of 398,000,000 dollars in the fourth quarter of 1950. The gold and dollar reserves, the Chancellor added, rose during the second quarter by 109,000,000 dollars and amounted to 3,867,000,000 dollars on June 30th, compared with 3,758,000,000 dollars on March 31st.

The Chancellor went on to say that one of the factors responsible for the decline in the surplus during the second quarter was increased expenditure on imports from the dollar area, both by the United Kingdom and by countries in the rest of the sterling area. Another factor was a decline in earnings from exports from the rest of the sterling area to the dollar area, which was in part seasonal. Against that, but only partly offsetting it, United Kingdom exports to the dollar area had shown a welcome increase.

In a subsequent statement at a Press conference, the Chancellor said that whilst raw material shortages and rising prices would continue to give concern, the problem of oversea balance was likely to return to the centre of the economic picture. In our own balance of payments and in the general sterling-dollar situation, we were entering a period of increasing difficulty. Exports, Mr. Gaitskell continued, would clearly need to be increased still further.

Later in his statement, the Chancellor said that, up to the end of May, industrial production was 5 per cent higher than in the corresponding months of last year. Although it was up to the estimate of 4 per cent mentioned in the Economic Survey for the year as a whole, it was well below the 9 per cent increase last year. He also stressed the importance of all possible economy in fuel consumption, pointing out that whilst coal output was less than 3 per cent above last year, home consumption was running 4 per cent higher. During the past few years the average rate of increase in electricity consumption had been 7 per cent, but now, the Chancellor said, it was running at something like double that figure.

Finally, the Chancellor referred to the employment situation, remarking that in the state of full employment it was important that mobility of labour should be encouraged. From one or two regions it had been suggested that there was some hidden under-employment. It was thought that firms were holding on to their labour in the hope that the raw material situation would improve, and workers were reluctant to transfer to new jobs. That, the Chancellor observed, was most undesirable.

The National Union of Mineworkers

During the annual conference of the National Union of Mineworkers, which was held at Blackpool last week, some details were given of the National Coal Board's pension scheme for miners. All mineworkers in the employ of the Board, between the ages of sixteen and sixty-four, qualify for membership of the scheme if they are in work which makes them eligible for the supplementary injuries scheme for mineworkers. Underground workers will contribute 1s. 6d. a week and surface workers 1s. 3d., the Board's contributions being 2s. and 1s. 8d. respectively. As the additional week's paid holiday could not be granted this year, the National Coal Board has agreed to start off the pension scheme with an initial payment of £2,000,000. In addition, it will be necessary for the Board to make a deficiency payment to the funds of the scheme for twenty-five to thirty years to meet the cost of back service credits and the additional cost caused by the late age of joining of many of the first members. The scheme is to begin as soon as practicable after it has been agreed between the Coal Board and the union, and received the approval of the Minister of Fuel and Power.

In an address to the conference on Thursday of last week, Lord Hyndley, the retiring Chairman of the National Coal Board, called for a new attitude of mind which meant "thinking big, thinking ahead and thinking in terms of success." Such an attitude, he said, would assuredly bring about that spirit of common endeavour on which so much depended. It was of the utmost importance, Lord Hyndley continued, that the coal mining industry should move quickly. The security of employment which the industry's key position had given the miner would not be lessened by speedy development of its resources, and every new machine and technique that could be found and applied efficiently would add to the industry's usefulness. That, Lord Hyndley suggested, would be no bad thing either for men or management. The last three years had seen big increases in productivity which had helped to produce more coal and which had been reflected in the industry's financial results. Lord Hyndley hoped that it would not be long before the industry's financial deficit was finally wiped out and some money put to reserve. The principal aim, however, must be to get more coal. He believed that coal would be more and more efficiently used as time went on, but even so, it would be a hard job for the industry to keep pace with demand.

Railway Wages

At a private session of the annual conference of the National Union of Railwaymen at Hastings last week, consideration was given to the report of a special committee on wages and conditions, which was appointed last March. Later, the general secretary of the union, Mr. J. B. Figgins, stated that the conference had adopted the report, which recommended that the union should go forward with a claim for a substantial wage increase. The report suggested that the executive of the N.U.R. should invite the other railway unions to consult with it on the subject of a common claim. Another recommendation by the committee related to negotiations for pensions for all grades of railway workers, increased payment for Bank Holiday duty and other holiday working, and for lodging and meal allowances.

Iron and Steel Production

Statistics issued this week by the British Iron and Steel Federation show that, during the month of June, the output of steel ingots and castings averaged 307,800 tons a week, and was thus at an annual rate of 16,007,000 tons. In May, the annual production rate was 15,864,000 tons and in June last year it was 16,249,000 tons. Steel output over the first half of this year was at an annual rate of 16,306,000 tons, and was therefore above the estimate of 16,000,000 to 16,250,000 tons given in this year's Economic Survey.

Pig iron production in June averaged 182,600 tons a week, which represented an annual rate of 9,497,000 tons, compared with a rate of 9,474,000 tons in June, 1950. The annual output rate during the first half of this year was 9,506,000 tons, compared with a rate of 9,611,000 tons in the corresponding period of last year.

British Non-Ferrous Metals Federation

The sixth annual general meeting of the British Non-Ferrous Metals Federation was held in Birmingham on Thursday of last week. Mr. W. J. Terry was elected President and Mr. H. E. Jackson, Mr. H. C. Gibbins and Mr. W. F. Brazener were elected Vice-Presidents.

In reviewing the Federation's work during the past year, the retiring President, Mr. W. H. Henman, referred to the ever-increasing costs of raw materials and to the fact that the demand for metal and metal products, which a year ago appeared to be falling off, was now higher than ever and greatly in excess of the capacity to supply. It would be unwise, however, he suggested, to take a superficial view of the present situation. The fact must not be overlooked that a great deal of what was regarded as demand was highly artificial, and was not really a demand for current consumption. There was the obvious example of stockpiling of copper, zinc, nickel and other materials by the U.S.A. and other nations, including our own. A policy of stockpiling, Mr. Henman pointed out, withdrew part of the annual production of metal from annual consumption, and thereby reduced the quantity available for normal uses, but it did not actually consume the metal which remained available in case of need. That, Mr. Henman continued, might be some comfort to the primary producer, whose rate of output was unimpaired, but it caused considerable concern to the fabricator, who still found himself obliged to curtail output, with all the consequences which it might involve in idle plant, increased overhead costs and redundancy of labour.

Mr. Henman went on to say that any real improvement in the international situation might substantially change the position of the non-ferrous metals industry. He hoped that the industry was prepared to pursue a very flexible policy and that it would be ready for rapid changes both in the supply of raw materials, the demand for its products and the prices of both. At home and abroad, he added, the demand for the industry's products had been, and continued to be, far in excess of what could be supplied at present from the raw material made available. Finally, Mr. Henman said that he was happy to learn that the Washington conference was paying great attention to the question of prices, because it was clear that any system of allocation must break down unless the quantities allocated were available to all at a uniform price, which should preferably be as low as possible.

Raw Materials and Redundancy

The Minister of Supply, Mr. Strauss, was asked in Parliament on Monday last what steps he was taking to ensure the employment of men in engineering works affected by the shortage of raw materials, and what financial arrangements were being made to cover the uneconomic working of plants.

In his reply, the Minister expressed regret that he could not ensure employment where there was a shortage of materials. The Minister of Labour, however, had asked employers, through their associations, to let local employment offices know in good time where there was likely to be redundancy. Trade unions had also been asked to advise workers whose jobs were coming to an end to register at local offices while they were still employed, so that there might be an opportunity of helping them to find other work without any interval of unemployment.

On the subject of the financial arrangements of engineering firms, the Minister said that they were matters for the managements concerned.

Coal Stocks and Fuel Policy

The Minister of Fuel and Power, Mr. Noel-Baker, stated in Parliament on Monday last that, on June 30th, the total distributed stocks of coal were 12,500,000 tons, which was an amount 1,100,000 tons greater than on the corresponding date a year ago. The Minister also said that he hoped very shortly to announce the names of the new committee to investigate some of the wider aspects of fuel policy. As stated in our last issue, the committee is "to consider whether any further steps can be taken to promote the best use of our fuel and power resources, having regard to present and prospective requirements, and in the light of technical developments."

Notes and Memoranda

Rail and Road

CAR PARKING IN LONDON.—A working party, under the chairmanship of Mr. A. Samuels, A.M.I.Mech.E., of the London and Home Counties Traffic Advisory Committee, has been set up by the Minister of Transport to consider the Traffic Advisory Committee's recommendations on car parking in the inner London area.

ROYAL STATISTICAL SOCIETY AWARD.—At the recent annual general meeting of the Royal Statistical Society, the President, Professor A. Bradford Hill, presented to Mr. F. A. A. Mehzler, chief development and research officer of the London Transport Executive, the Society's Guy Medal in silver for his paper entitled "London and its Passenger Transport System."

LEVEL CROSSINGS.—The Minister of Transport has recently stated that the only public road level crossings without gates are those over railways constructed under Light Railway Orders. There are approximately 370 such crossings in the United Kingdom, five of which are in Cornwall. In the twelve months ended May 31st, the Minister said, there were fifteen accidents on these crossings in the United Kingdom.

REGULATIONS FOR PEDESTRIAN CROSSINGS.—The Minister of Transport has made new regulations governing the use and marking of pedestrian crossings. They will come into operation on October 31st next, when all existing pedestrian crossing regulations will be revoked. Under the new regulations pedestrians will have priority over vehicular traffic at uncontrolled crossings only. The pedestrian's precedence at controlled crossings, i.e., where there are light signals or police control, will be abolished, and the Highway Code will be amended to give road users guidance on the use and observance of such crossings. Uncontrolled crossings will be marked by a pattern of alternate black and white stripes. It has been decided to retain, for the time being at least, the use of studs in the marking of all crossings whether controlled or uncontrolled, and also the use of beacons for uncontrolled crossings. The new regulations also contain provisions under which local authorities may impose in suitable places a prohibition, subject to the usual exemptions for loading and unloading of vehicles, on the waiting of vehicles within 45ft on the approach side of pedestrian crossings. The limit of the prohibited length will be marked by a new sign painted on the kerb or edge of the road.

Air and Water

DR. GEORGE WEBSTER'S RETIREMENT.—Lloyd's Register of Shipping states that Dr. George Webster, Principal Surveyor for Scotland, will retire at the end of September after thirty-seven years' service with the Society. His earlier career included over six years in London, a short time in Japan, nearly five years at Gothenburg, and a year in Oslo. When he was appointed senior ship surveyor, Glasgow, in 1933, he had already had two previous periods of service at that port. He became principal surveyor at Glasgow in 1935, and principal surveyor for Scotland in 1944. On Dr. Webster's retirement, Mr. H. R. Gibbs, who has been senior ship surveyor at Glasgow since March, 1950, will become principal surveyor for Glasgow. Mr. J. R. Clark, B.Sc., who has been in charge of the plans department under Dr. Webster since October, 1940, will become a principal surveyor for the approval of plans of new ships to be built in Scotland. Mr. Gibbs will be succeeded as senior ship surveyor at Glasgow by Mr. H. McQueen, who is at present stationed at Newcastle.

RESEARCH SHIP "DISCOVERY II."—The Royal Research Ship, "Discovery II," which is operated by the National Institute of Oceanography, left Port Stanley, Falkland Islands, on July 4th, on the third stage of her circumpolar voyage. She is carrying out a general oceanographical survey of the biological and physical conditions in the Southern Ocean. She left Sydney on May 21st on the first stage of the voyage and, after a few days at Dunedin, sailed southward for the long second stage in the Pacific Sector of the Antarctic. Oceanographically this region is almost unknown at this time of the year. After reaching the pack ice she altered course to the eastward and skirted the ice edge until June 24th, when she altered course for the Falkland Islands. Fine weather was experienced in the early part of this voyage, but the ship later encountered gales, rough seas and heavy swells. During the third stage of the voyage, which has just begun, the ship will again proceed south to the ice, visiting the Burwood Bank and the deep water known as the South Sandwich Trench. She expects to arrive at Simonstown, South Africa, on July 28th. She will then visit Durban before starting on the last stage of the voyage, which will include a visit to the French scientific expedition on the lonely island of Kerguelen, and will end at Fremantle about the middle of September. The ship carries a scientific staff of eight members, headed by Dr. H. F. P. Herdman, of the National Institute of Oceanography, and a crew of forty-eight officers and men.

Miscellanea

THE LATE MR. H. C. MILLS.—We have learned with regret of the death of Mr. H. C. Mills, which occurred suddenly on June 27th. Mr. Mills was managing director of the Morgan Crucible Company, Ltd., Battersea Church Road, London, S.W.11.

SUPPLEMENTARY DEFENCE ESTIMATE.—A supplementary estimate for an additional £6,000,000 required in the current financial year has been presented to the House of Commons by the Minister of Defence. The money is needed, it is stated, to meet extra expenditure created by developments in the defence organisation of the North Atlantic treaty area.

BRITISH PURCHASING COMMISSION TO EUROPE.—The European Purchasing Commission, which has been set up by the Minister of Supply to encourage procurement in Europe of stores and equipment required for the United Kingdom's defence programme, has now opened offices in Belgium, Germany, France, Italy and Switzerland. The Commission has also appointed representatives in Spain and Denmark.

ATOMIC POWER FOR INDUSTRIAL PURPOSES.—In the course of a reply to a question in Parliament on July 9th, the Minister of Supply said that no reliable estimate could yet be made of the relative cost of generation of electricity by present methods and from atomic power. There was, however, a reasonable prospect that generation from atomic power could be developed on a large scale, and that ultimately the cost would not differ greatly from that of power from conventional sources. Generation from atomic energy was likely first to offer advantages in particular places, but at present it was too early to form conclusions or to prepare plans for action.

AUTOMOBILE ASSOCIATION'S ANALYSIS OF BREAKDOWNS.—An analysis made by the Automobile Association of a number of car breakdowns shows that the most frequent causes of trouble were flat batteries (18·7 per cent) and punctures (14·9 per cent). Electrical faults totalled 45·7 per cent; in addition to flat batteries they included ignition (6·3 per cent) and lights, wiring and fuses (5·5 per cent). Under the general heading of fuel troubles were running out of petrol (6·5 per cent), blocked petrol feed (3·1 per cent), carburetter (2·6 per cent) and petrol pump (2·4 per cent). Among mechanical breakdowns the most common were jammed starters (3·7 per cent). Clutch and gearbox failures accounted for 3·5 and 3·3 per cent respectively. Transmission troubles numbered 3·4 per cent and included broken back axle half-shafts (2·4 per cent)

CAPACITORS FOR IMPROVING TRANSMISSION SYSTEM PERFORMANCE.—The British Electricity Authority has decided to use e.h.v. shunt capacitors to improve the performance of a section of its overhead transmission line system. The initial installation in South Wales will be of considerable interest as it will be the first time that 11kV and 33kV shunt capacitors have been used by the Authority for the improvement of system power factor. The Authority has ordered from British Insulated Callender's Cables, Ltd., 22,500kVAr of capacitors which, when connected, will improve power transmission conditions into South Wales and will thus help to meet the serious power supply difficulties likely to occur in an important industrial area towards the end of 1951. Of the above total, 12,000kVAr will operate on the 33kV system, and the balance of 10,500kVAr at 11kV. Although not previously adopted in this country, the method is an established practice in North America, and the B.I.C.C. has recently provided a number of large high-voltage capacitor banks to supply undertakings in Canada.

Launches and Trial Trips

KADOURA, refrigerated cargo vessel; built by J. Samuel White and Co., Ltd., for the Compagnie Maritime des Chargeurs Reunis; length between perpendiculars 328ft, breadth moulded 50ft 6in, depth moulded to upper deck 32ft 9½in, draught 20ft 8in, deadweight 2520 tons; two Burmeister and Wain single-acting, two-cycle diesel engines, each eight cylinders 500mm diameter by 1100mm stroke, total b.h.p. 6500 at 165 r.p.m. Launch July 5th.

CHAKDARA, cargo liner; built by Barclay, Curle and Co., Ltd., for the British India Steam Navigation Company, Ltd.; length 485ft, breadth 62ft 6in, depth to shelter deck 40ft 9in., gross tonnage 9000; Barclay Curle-Doxford oil engine, six cylinders, 670mm diameter by 2320mm combined stroke, 6800 b.h.p. at 116 r.p.m., steam auxiliary machinery, two cylindrical multitubular boilers. Launch June 25th.

FRANCE STOVE, motor tanker; built by Harland and Wolff, Ltd., for Lorentzen and Co., Oslo; length between perpendiculars 580ft, breadth moulded 78ft, depth moulded to upper deck 42ft 6in, deadweight 24,000 tons; Harland-Burmeister and Wain single-acting, two-cycle, opposed-piston oil engine, seven cylinders, 750mm diameter by 2000mm combined stroke, 110 r.p.m., two cylindrical multitubular boilers. Launch July 2nd.

Contracts

THE BURNTISLAND SHIPBUILDING COMPANY, Ltd., has contracted to build for the Compania de Navegacion Oriental de Panama, of Panama, a 10,500 tons deadweight cargo ship, propelled by a Sulzer diesel engine of 4900 b.h.p.

VICKERS-ARMSTRONGS, Ltd., is to build at its Barrow shipyard two more 32,000 tons deadweight oil tankers for the North American Shipping and Trading Company (London), Ltd. Both vessels will be powered by geared steam turbines.

J. AND A. BROWN AND ABERMAIN SEAHAM COLLIERIES, Ltd., Australia, has placed an order with the Burntisland Shipbuilding Company, Ltd., for a self-trimming collier of 1800 tons deadweight. The propelling machinery will be a British Polar diesel engine of 1230 b.h.p.

Personal and Business

THE RAILWAY EXECUTIVE announces the appointment of Mr. J. Ratter, C.B.E., M.I.C.E., as chief officer, engineering (works), at headquarters.

THE HON. LEWIS W. DOUGLAS and Mr. I. C. Raymond Atkin have been elected to the board of the International Nickel Company of Canada, Ltd.

CAPTAIN R. W. RAVENHILL, R.N. (Ret.), has been appointed naval representative of the Sperry Gyroscope Company, Ltd., Great West Road, Brentford.

THE MINISTER OF TRANSPORT has appointed Professor A. N. Shimmin to be chairman of the Transport Users Consultative Committee for the Yorkshire area.

THE SKEFKO BALL BEARING COMPANY, Ltd., has opened a new branch office at 141, Dale Street, Kingsway, Liverpool, 2 (telephone, Central 7226). Mr. E. Buckley is in charge.

DUREX ABRASIVES, Ltd., states that its name has been changed to Minnesota Mining and Manufacturing Company, Ltd. The address of the company is Arden Road, Adderley Park, Birmingham, 8.

MR. WILLIAM JONES has been appointed manager of the Bristol office of Brookhirst Switchgear, Ltd., in succession to the late Mr. H. J. Barber. Mr. Jones has been in the company's service for thirty years, including seventeen years in the London area.

ELECTRO-HYDRAULICS, Ltd., states that its fork truck division has been incorporated as a separate private limited company and that it now operates under the title of Conveyancer Fork Trucks, Ltd., with registered office at Liverpool Road, Warrington.

MR. J. P. A. MELDRUM, M.I.E.E., has been appointed special assistant, sales management, and Mr. J. E. Stubbs, A.M.I.E.E., has been appointed sales manager, switchgear department, of Metropolitan-Vickers Electrical Company, Ltd., Trafford Park, Manchester.

THE COLEMAN WALLWORK COMPANY, Ltd., is the name of a new company combining the interests and activities of the Coleman Foundry Equipment Company, Ltd., and Stone-Wallwork, Ltd. The company, which is a subsidiary of J. Stone and Co., Ltd., has its offices, workshops and research departments at Windsor Works, Stotfold, Beds, with area offices at 157, Victoria Street, London, S.W.1, and 12, Bulldale Street, Glasgow, W.4.

THE BRUSH ABOE group of companies announces the following appointments:—Mr. John Ayres, M.I.E.E., general manager of Petters Ltd., Staines; Mr. C. F. Barnard, assistant general manager, National Gas and Oil Engine Company, Ltd., Ashton-under-Lyne; Mr. E. J. Batchelor, vice-chairman, Brush Coachwork, Ltd.; Mr. K. N. Eckhard, M.I.E.E., director and general manager, Brush Bagnall Traction, Ltd.; Mr. B. D. Giordan, A.M.I.Mech.E., general manager, Mirrlees, Bickerton and Day, Ltd.

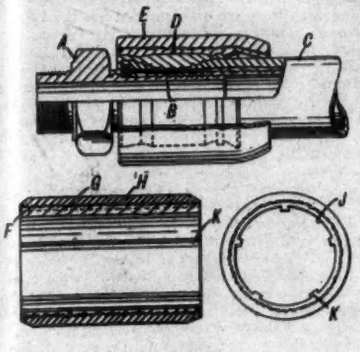
British Patent Specifications

When an invention is communicated from abroad the name and address of the communicator are printed in italics. When an abridgment is not illustrated the specification is without drawings. The date first given is the date of application: the second date, at the end of the abridgment, is the date of publication of the complete specification. Copies of specifications may be obtained at the Patent Office Sales Branch, 25, Southampton Buildings, Chancery Lane, W.C.2, 2s. each.

TUBE AND PIPE COUPLINGS

653,855. November 4, 1948.—Fire-Resisting Hose Couplings, The British Tyre and Rubber Company, Ltd., Thomas Alfred Beazley, both of Herga House, Vincent Square, London, S.W.1, and Wilfred Bowden, of the Company's Works, Golden Hill Lane, Leyland, Lancashire.

The hose unit shown in the drawing comprises a metal coupling *A* providing an insert *B* fitting into the end of a hose portion *C* and a metal sleeve *D* swaged around the end of the hose to grip the end against the insert. Around the sleeve is a



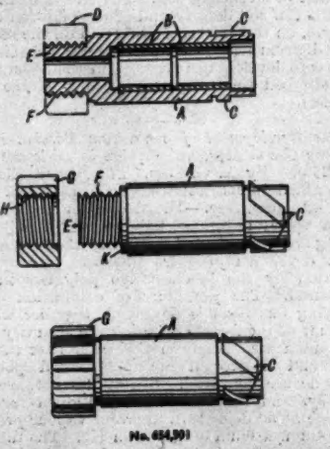
No. 653,855

fire-resisting protective sleeve *E* (shown in greater detail in the lower views). It consists of an inner layer *F* of rubber, a layer *G* of asbestos, and an outer layer of rubber *H* with or without an external wrapping of tape. The inner layer is formed with longitudinal grooves *J* between narrow ribs *K*. These extend the whole length of the sleeve and provide air spaces between the protective sleeve and the coupling sleeve. A modified form of protective sleeve in which the inner layer is formed with internal bosses which engage the coupling sleeve so that air spaces are provided between the bosses is also described in the specification. Auxiliary holding means for securing the fire-resisting sleeve in position comprise a clip or a wire binding.—*May* 30, 1951.

MISCELLANEOUS

654,501. October 8, 1948.—Electric Starting Gear for Engines or Machines, Clifford Edward Owen, of 3, Deneford Road, Didsbury, Manchester, 20.

The object of this invention is to facilitate the replacement of damaged axial starter pinions and to reduce the cost of such replacement. The upper drawing shows the body of the starter pinion unit to be reconditioned, which comprises a brass or

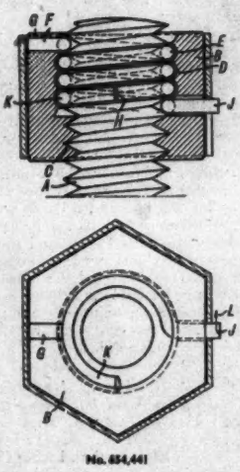


No. 654,501

other metal sleeve *A* having a stepped bore the central part of which accommodates a renewable bearing bush or bushes *B*. At one end of the sleeve *A* are the external helically arranged splines *C* constituting the quick-thread, whilst at the other end of the sleeve are the integral pinion teeth *D* in so worn a condition as to render the unit unserviceable. In reconditioning the unit, the teeth are turned off to leave that end of the sleeve with a concentric spigot *E*. This spigot may be 1in in diameter in the case of a sleeve 1·375in overall, and its length may correspond to the width of the original teeth, say, ¼in. The spigot *E* has formed on it a screw thread *F* of opposite hand to the quick-thread *C*, and the removed teeth *D* are replaced by a toothed annulus *G* having a complementary internal thread *H*. The pinion *G* can readily be screwed on to the sleeve *A* while it is operatively associated with the friction clutch through which the drive is to be transmitted. This greatly facilitates any subsequent reconditioning of the starting gear, since, when the pinion *G* itself becomes worn, it can be renewed without dismantling the clutch assembly.—*June* 20, 1951.

654,441. May 4, 1948.—Locking Device for Threaded Machine Elements, Folke Rydberg, of Olaigatan 35, Orebro, Sweden.

In the drawing *A* is a threaded bolt and *B* a nut screwed on to it. The nut has a thread *C* fitting the bolt thread, and an additional thread *D* of greater diameter, which extends over a portion only of the length of the nut. In the thread *D* is inserted a helical locking spring *E*, the outer end *F* of which is retained in a radial groove *G* provided in the nut. The inner end of the locking spring is indicated at *H*. Below the locking spring there is provided a wire *J* extending in the additional thread *D* through an angle of at least 180 deg. The inner end of the wire is normally located at a



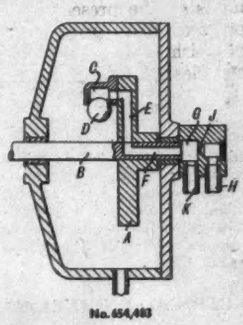
No. 654,441

slight distance from the inner end of the locking spring, or may normally contact the end *H* without exerting a pressure on it. The outer end *J* of the wire *K* extends substantially radially through an opening in the nut so that it can be actuated from the outside. Normally, the unscrewing of the nut is prevented by the locking spring *E*. If, however, a force acting in the direction of the arrow *L* is applied to the outwardly bent end *J* of the wire, it will be turned within the thread *D* and its inner end will be forced against the inner end *H* of the locking spring, so as to expand the spring, with the result that the nut can be unscrewed. The force acting on the end *J* of the wire may be applied manually, such as by a finger or by means of a suitable tool illustrated in the specification.—*June* 20, 1951.

654,403. January 9, 1948.—Speed and Acceleration-Responsive Devices, The Harland Engineering Company, Ltd., of Harland House, 20, Park Street, London, W.1 (*Inventor: Nicolas Worthing*).

This invention relates to speed-responsive devices which translate changes of speed into changes of pressure of a liquid, which is used to effect a control as in speed governors. In the drawing the rotary member which is subject to the speed changes to which the device is required to respond, comprises an arm *A* keyed to a shaft *B* driven by a prime mover. The arm carries at a suitable radius from the shaft an oil chamber *C* having a circular opening facing towards the shaft with a floating ball valve *D* disposed between the opening and the shaft. An oil passage *E* connects the oil chamber to a hollow portion of the shaft *F* leading to an adjacent stationary chamber *G*. Oil from a pressure supply is led in by a pipe *H* through a constriction *J* into the chamber *G*, and passes along the connecting passages into the revolving chamber *C*, whence it escapes through the opening controlled by the ball valve. In operation there are two opposing forces acting on the floating ball, namely, the outward centrifugal force on the ball and the inward force due to the oil pressure in the revolving chamber.

If the latter force is the greater, the ball lifts slightly off its valve seat and the resulting flow or increase in flow of oil past the ball valve drops the pressure in chamber *C*, due to the effect of the constriction. Thus, the ball automatically assumes a position in which the two opposing forces are equal, and the pressure in the chamber is proportional to the centrifugal force or the square of the speed. The pressure in the stationary chamber *G* is equal to the pressure in chamber *C* less the centrifugal head of the oil column at the radius of



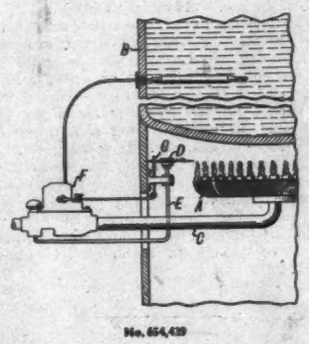
No. 654,403

the valve seat. This centrifugal head is also proportional to the square of the speed. Thus, the pressure in the stationary chamber *G* is also proportional to the square of the speed. Provided the supply pressure is maintained above a predetermined value, the pressure in chamber *G* will not be affected by variations in the supply pressure, but will be dependent only on the speed of the rotary member *A*. A drain pipe drains the escaped oil out of the casing. A pipe *K* transmits this controlled pressure in chamber *G* to a remotely situated actuator which is sensitive to pressure variation. A flywheel type of governor is also described in the specification.—*June* 20, 1951.

OIL BURNERS AND SPRAYERS

654,429. March 31, 1948.—Electromagnetic Control Apparatus for Fluid Fuel Burners, Robertshaw-Fulton Controls Company, of Delaware, Youngwood, Pennsylvania, U.S.A.

Referring to the drawing, the main burner *A* of a water heater *B* is supplied with fuel through a pipe *C*; the pilot burner *D* for the main burner is supplied with fuel through a pipe *E*. The fuel



No. 654,429

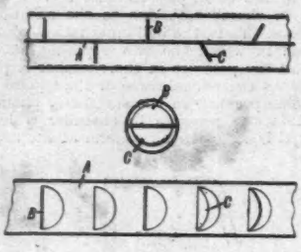
supplied to both the main and pilot burners is controlled by the apparatus *F* of the invention. The pilot burner produces a flame which serves to heat an adjacent thermocouple element *G*, and upon extinguishment of the pilot burner flame the thermocouple *G* cools and causes the gas supply to the main burner *A* to be cut off by operation of the control apparatus *F*, which is fully described and illustrated in the specification.—*June* 20, 1951.

HEAT EXCHANGERS

654,610. December 3, 1948.—Oil Coolers, Serck Radiators, Ltd., of Warwick Road, Greet, Birmingham, 11; Fraser Robson and George Alan Montgomerie, both of the company's address.

Referring to the drawings, there is provided a strip *A* of metal, the width of which is equal to the internal diameter of a tube, and from this strip there are pressed in opposite directions central deflector pieces *B*, which may extend at right angles to the strip towards the inner surface of the tube, or they may be arranged to extend at any desired angle, and so enable gaps of any desired width to be formed between them and the tube, as shown at

C. The arrangement is such that the liquid flowing along the tube is successively deflected from the central region to the inner surface of the tube. The warmer oil in the central region is thereby



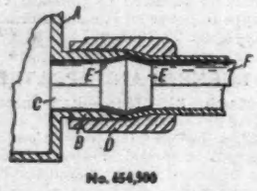
No. 654,610

caused to mix with the chilled oil adhering to the tube surface, and so prevent or minimise the normal tendency for a stagnant layer of chilled oil to remain attached to the tube. Whilst the invention is primarily intended for use in oil coolers, it may be used in coolers for other viscous liquids.—*June* 20, 1951.

ELECTRICAL ENGINEERING

654,500. October 6, 1948.—SEPARABLE ELECTRIC JOINTS OR COUPLINGS, Robert Greens Grubb, of 27, Gardner's Crescent, Edinburgh, 3, and Stewart William Macdonald Morris, of 12, Robertson Avenue, Edinburgh, 11.

This invention is concerned with electric couplings for earthing or ensuring electric conducting continuity between insulating conduits of plastic material and junction boxes, or the like, of metal or insulating material. The drawing shows a part of an electric junction box *A* and a tubular branch



No. 654,500

member *B* extending from it. A metallic wire or ribbon *C* is embedded in and conforms to the inner surface of the box and branch member. The conduit is provided with a metal wire or ribbon *F* embedded in the surface of the insulating material and conforming to the contour of the inner surface. A hollow coupling member or nut *D*, internally screw-threaded at one end to co-operate with the screw thread on the member *B*, is provided for maintaining the member plug *E* and the conduit connected to one another. It will be seen that the metallic parts of the box, the branch member, the plug and the conduit form a continuous electrically conductive path for earthing purposes. Modified arrangements for coupling a non-metallic conduit to a metallic junction box and a pair of non-metallic conduits are also shown in the specification.—*June* 20, 1951.

Forthcoming Engagements

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of their insertion, the necessary information should reach this office on, or before, the morning of the Monday of the week preceding the meetings. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

Incorporated Plant Engineers

Wed., July 18*th.*—E. MIDLANDS BRANCH: Evening Visit to General Refractories, Ltd., Workshop.

Sat., July 21*st.*—BIRMINGHAM BRANCH: Morning Visit to B.E.A., Hams Hall "B" Station.

Old Centralians

To-day, July 13*th.*—Chez Auguste Restaurant, Frith Street, W.1, "Engineering Potentialities and Opportunities in Afghanistan," W. Abbott, 12.55 p.m.

Royal Meteorological Society

Wed., July 18*th.*—Summer Meeting at East Malling Research Station, East Malling, Maidstone.

Technical Reports

A German Cyclone Furnace. Information Bulletin No. EG 51 (7), National Coal Board, Production Department.—The information contained in this bulletin is based on a visit to Germany of a team consisting of Mr. B. L. Metcalf, Mr. R. M. Marson, and Mr. F. B. Karthauser. Parallel with the work done in the United States, the development of slagging and cyclone furnaces has proceeded in Germany during the last ten years. German colliery engineers believe that cyclone furnaces could be used with advantage at collieries for burning high ash fuels, because they discharge most of the ash in liquid form, and the quantity of ash discharged as dust is reduced; as a result, ash disposal difficulties are lessened, especially as the liquid slag, after having been granulated in water, can be used for making building material and for filling up roads, &c.

The development of a cyclone furnace has been in process in a Dusseldorf power station, the work being carried out by STEAG in conjunction with B. and W., Oberhausen. A cross section through the boiler and furnaces is shown in the report. The boiler, which had originally been equipped with a chain grate stoker, had to be rebuilt to suit the cyclone furnace. The steaming capacity of the cyclone, which has been designed along the lines of the Calumet cyclone, is 66,000 lb per hour, the heat release being 500,000 B.Th.U. per cubic foot per hour. The fuel burned in the cyclone has approximately the following composition:—Volatile matter, 24 per cent; ash, 5 per cent; water, 4 per cent; net calorific value, 13,000 B.Th.U. per pound. The coal is crushed to a top size of 5mm in a crusher located above the cyclone feeder. The cyclone is equipped with a gas burner in order to permit quick starting.

The plant had been in operation for about two months when it was visited in August, 1950. Although the plant was designed according to American experience, there were initial difficulties similar to those at Calumet and Dow Chemical in U.S.A., especially with burnt-out cooling tubes inside the cyclone. These troubles had, however, been overcome and STEAG stated that the furnace had proved to be efficient and reliable with coal of the composition given above, and that the intention was to try slurry, aspirated dust and middlings of high ash content. Coals with varying volatile contents were also to be tried. No attempt has been made to run the cyclone at the lowest limit of loading, but operating engineers assume that it can be operated at 50 per cent load without the ash in the cyclone becoming solid.

Gas Blast-Circuit Breakers: Aerodynamic Conditions in Nozzle as Affected by Arcing and Nozzle Diameter (Ref. G/T234). By A. M. Cassie, M.A., M.I.E.E., F.Inst.P., and A. A. Hudson, B.Sc., Wh.Sc. The British Electrical and Allied Industries Research Association. Price 12s. 4d. post free.—This publication is a progress report on the study of air flow in circuit breakers. It describes a series of tests, in which the influence of the arc upon the mass of air flowing through the nozzle has been examined for a range of currents (I) from 1500A to 7500A r.m.s., and of nozzle diameters (d) from 1·0cm to 2·5cm. It is found that, for the above ranges of current and nozzle diameter, the ratio of apparent mass-flow during the whole arcing period to the mass-flow during the same period with no arc present is a function of $I/d^{1\cdot 6}$.

A Device for Negotiating Face Disturbances with a Scraper Chain Conveyor. Information Bulletin No. MM (51) 7, National Coal Board, Production Department.—This bulletin gives details of a device developed in the West Midlands Division for holding down a scraper chain conveyor on a long-wall face where disturbed geological conditions are encountered. On the particular face for which the device was developed a fault with a throw of 10ft was successfully negotiated, but it can be used to hold down the conveyor in any depression in the face where the top chain has a tendency to rise from the pan or the tension in the bottom chain is so great as to lift the whole structure bodily from the floor.

The device applied to a Cowlishaw Walker 20in conveyor consists of two main members—4ft 7in by 8in by 3½in channel beams, which are securely held on the floor by props at either end. The master section of the conveyor rests on these channels in a seating formed by cutting away the flanges, the bottom pan being welded to the beams. Welded to the channel irons, two on each side of the conveyors, are fabricated welded pillars, to the top of each of which is bolted one end of a plate, 9½in by 6½in by ½in, chamfered at the edges, so that the other end of the plate protrudes through a slot 8in by 1½in cut in the side of the top pan. These plates serve to hold down the top chain, the lateral play in which is restricted at this point by 1½in by ½in flat guides welded below the slots and against the bottom of the top pan. The bottom chain is prevented from bearing against the underside of the top pan by six 3½in lengths of 2in by ½in flat strip welded by their long edges to the sides of the bottom pan. These flats are stellited on the underside to give a good wearing surface, and are slightly turned up at each end to permit the chain to pass smoothly under them.

With this design of conveyor adjacent sections are fastened together with a T-shaped clamp, the wings of which engage with two lugs, one on each of the sections. In order that the master section should butt correctly against the next section at the change of gradient, the ends of the master trough are cut at an appropriate angle. To facilitate fastening at this angle, one wing of the T-shaped clamp must be bent upward to ensure that it shall engage with its fastening lug.

Restriking Voltage in British 66kV Networks (Ref. G/T239). By L. Gosland, B.Sc., M.I.E.E., and J. S. Vosper, B.Sc. (Eng.) The British Electrical and Allied Industries Research Association. Price 7s. 9d., post free.—This report contains a summary of work done to date by the E.R.A. in determining the maximum values for the rates of rise of restriking voltage likely to be encountered on British 66kV networks. As far as practicable, every circuit breaker position has been considered and the R.R.R.V. values appropriate to the circuit, giving maximum rates of rise and maximum fault current, have been calculated. The values so obtained are used to derive characteristic curves covering the duties to which various percentages of all breakers are subject.

The Maximum Energy Dissipated during First Current Loops of Different Asymmetry on Closing an A.C. Series Circuit (Ref. G/T250). By H. Goldenberg, B.Sc., A.R.C.S. The British Electrical and Allied Industries Research Association. Price 6s. 3d., post free.—This report deals with mathematical methods for determining the energy dissipated in certain circumstances which are of interest in the general study of circuit-breaking phenomena. It is required to find the maximum energy dissipated in a resistance, in the first current loop, in a series circuit containing any values of fixed resistance and inductance, in which the point of start of current flow can be varied anywhere within a half-cycle of the applied sinusoidal voltage, the source of which is assumed to have negligible impedance. A useful picture of the phenomena involved in the above problem is obtained from the initial consideration of the envelope of the instantaneous power in the resistance for varying circuit parameters and varying instants of closure of the circuit.

The maximum energy for all asymmetries and any value of fixed inductance is shown to be 48 per cent greater than that of the corresponding symmetrical case and to occur when the ratio of resistance to inductive reactance is in the neighbourhood of 0·5. The maximum instantaneous power in the resistance for any value of fixed inductance and for all asymmetries is found to be 24 per cent greater than that of the corresponding symmetrical case, and to occur when the ratio of resistance to inductive reactance is in the neighbourhood of 0·64.

Electrode Soil Sterilising (Ref. W/T21). By A. E. Canham, M.Sc. (Eng.). The British Electrical and Allied Industries Research Association. Price 9s. 3d., post free.—This preliminary report gives the results of experiments on the current flow through the soil from rod electrodes in an investigation of the basic problems associated with this method of sterilising soil. The effects of moisture content, of soil density and of the addition of electrolyte, on the current flowing and on the temperature distribution in the soil, have been studied with a view to developing a practical method of sterilising tomato bed soil *in situ* using low-voltage transformers.

The Development of a Vacuum Torsion Balance and its Use to Measure Sorption in Dielectrics (Ref. L/T256). By A. G. Day. The British Electrical and Allied Industries Research Association. Price 12s. 4d., post free.—The design and construction of a vacuum torsion balance which will weigh 10^{-7} g is discussed in this report. The balance has been developed in order that the rate of water sorption by the less sorptive polymers may be measured. The procedure of calibration and of carrying out tests is described, together with an account of the factors affecting the accuracy of the measurements. Experimental results for the sorption and desorption of unplasticised polyvinyl chloride are compared with values obtained previously, and several results are given for polystyrene at 50 deg. Cent. at water vapour pressures of 9·4mm, 4·6mm and 2·8mm Hg. The diffusion coefficients are calculated both at the beginning of the sorption and after a few minutes when the initial high rate of sorption reaches a much lower value. It is suggested that surface adsorption may determine the shape of the mass-time curve during the first few minutes of the test.

THE ENGINEER

A Seven-Day Journal

Opening of the Margam and Abbey Steel Works

On Tuesday last, July 17th, the Margam and Abbey Steel Works of the Steel Company of Wales was officially opened by the Chancellor of the Exchequer. This works forms the major part of the £60 million scheme for the reconstruction of the South Wales sheet steel and tinplate industry, recommended by the Iron and Steel Federation shortly after the last war. For the scheme four companies—Guest Keen Baldwins, Ltd., Richard Thomas and Baldwins, Ltd., John Lysaght, Ltd., and the Llanelly Associated Tinplate Companies—pooled certain of their resources, valued at over £10 million. The scheme, which is not yet fully completed, given the suitable raw materials supplies, will eventually produce 15,000 tons of coke, 19,000 tons of pig iron and 30,000 tons of steel ingots per week. From these ingots there will be produced 3500 tons of rails and railway materials, and 22,800 tons of steel strip and plate a week. At a lunch which preceded the opening ceremony the Chancellor of the Exchequer said that this was the completion of a tremendous project, launched with foresight, courage and imagination over four years ago, when in many respects the economic prospect before the country was hard and cheerless. What had been done, he considered, was symbolic of what had been achieved by the British people as a whole by hard work, restraint, faith and courage during the difficult years since the end of the war. Steel, he said, was almost literally the backbone of all industrial investment, and without it investment would all but cease. He then paid tribute to all concerned with the design and construction of the works built on the 588-acre site.

Rubberised Bitumen for Highway Surfacing

It may be recalled that in our issue of May 5th, last year, an account was given of a trial length of rubberised asphalt carpet which had recently been laid in Acre Lane in Lambeth. Since that date a number of other trial stretches of highways have been resurfaced with a carpet or surface dressing using a rubberised bitumen. We were recently invited by the Rubber Development Board to see the first large-scale use of this material in this country, which is being carried out by the Leeds Highway Department to resurface about 22,000 square yards of the Leeds-Wetherby road (A58). Last year on the Selby road in Leeds a trial length of surface dressing was laid, from which it appears that the rubberised bitumen is superior to ordinary bitumen in adhesion to the road surface and the aggregate. It is stated that the extra cost of the rubberised bitumen will be justified if only one year is added to the life of the surface dressing. The present work consists of applying rubberised bitumen with a rotary brush sprayer at a cover of $^5/_6$ square yard to the gallon, used in conjunction with a gritting machine applying ¼in whinstone chippings at about 70/80 square yards to the ton, and consolidated by a 10/12-ton roller. The bitumen has a 60/70 penetration and is fluxed with a light creosote oil. Two per cent by weight of natural rubber powder ("mealorub") is added and heated with constant agitation for about three hours at 300 deg. Fah, after which the light creosote oil is added. The bitumen is delivered to the site in insulated road tanks at a viscosity of 300/320 seconds, standard tar viscometer, to be applied at a temperature of 280/300 deg. Fah. The contractors supplying the bitumen are Crowley Russell and Co., Ltd. As mentioned above, the main advantage expected is an increase in the life of the surface dressing, but a reduction in "bleeding" and increased stability at high atmospheric temperatures is also expected, since the viscosity of the rubberised bitumen, whilst being about the same as ordinary bitumen at 25 deg. Cent., is 15 per cent higher at 30 deg. Cent. and 25 per cent higher at 40 deg. Cent.

Non-Ferrous Ore Treatment and Dressing

A mission in which ten European countries were represented has completed an eight weeks' tour of the United States and Canada, during which a study was made of the methods of treatment and dressing of non-ferrous ores, under the auspices of O.E.E.C. Visits were made to three research laboratories; fifteen copper, molybdenum, and nickel plants; fifteen zinc, lead and silver plants; nine alluvial ore dressing plants. Three plants making heavy mining equipment were visited as well as a number of the principal university centres. The final report of the mission will be made in a few months, but notes on a few particular points of interest have been published. With regard to the various methods adopted, the mission noted the considerable importance which was attached to "planning" in the American plants, ranging from detailed forecasts of all phases of manufacture, starting well before the first operation and covering the disposal of the products. Another point mentioned by the mission was the size of a certain number of American plants and the special techniques employed to solve the problems set by the large quantities of products handled. Particular note was made of the methods used for conveying and unloading the ore. It was seen that in the American plants crushing was carried out in three or four stages, the second of which was in open circuit (maximum reduction) and the last in closed circuit. In the construction of heavy machinery heavy crushers were made of pig iron instead of steel, and there was a virtual absence in the United States of the controversy current in Europe over the comparative advantages of jaw crushers and gyratory crushers. In the U.S.A. the choice of equipment is determined by the opening and the capacity.

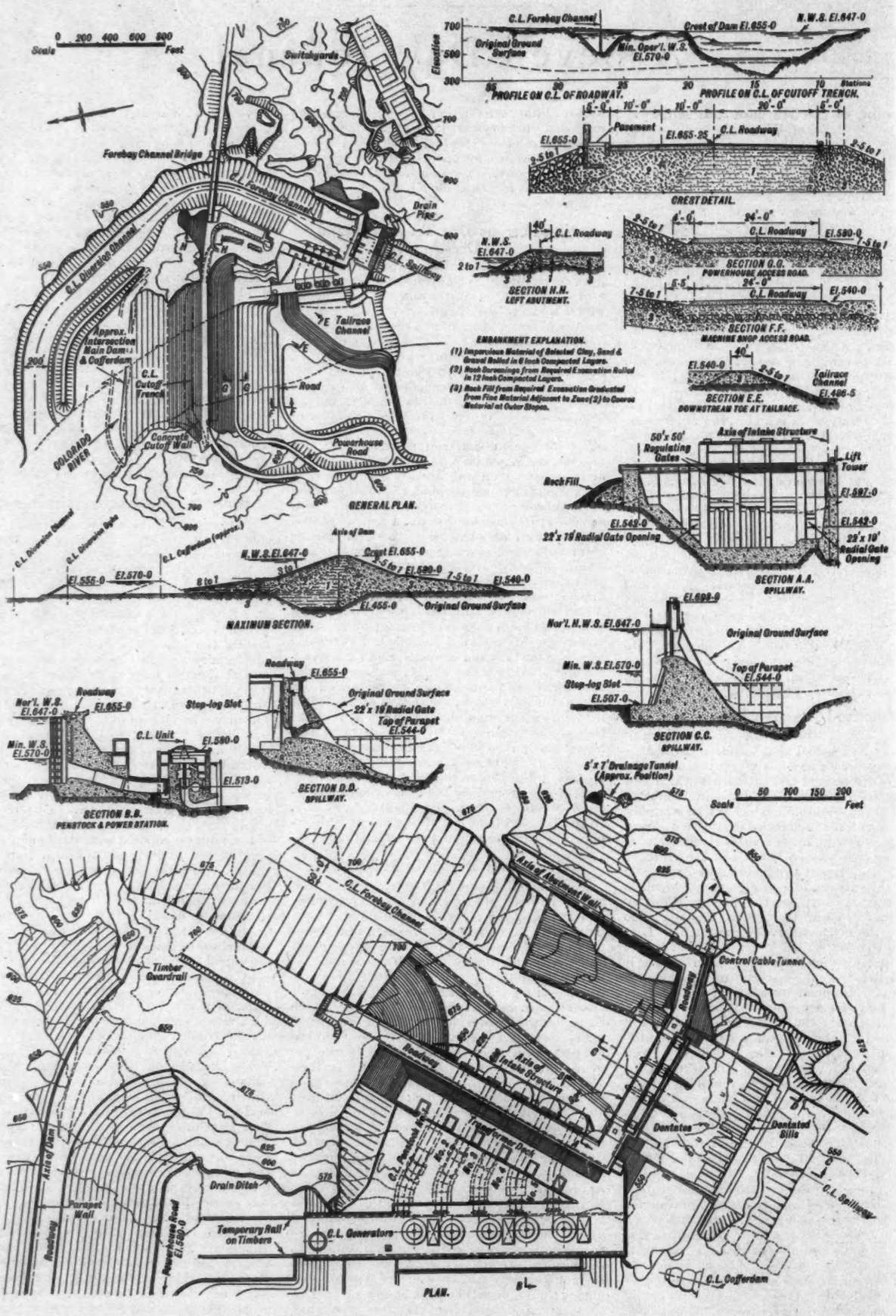
Alkali Works in 1950

The annual report of the chief alkali inspectors to the Minister of Local Government and Planning for the year 1950 has just been published. It expresses the opinion that better planning of chemical works, good roadways and the setting out of grass lawns and flower beds have not only produced more attractive conditions for the workpeople, but have made altogether more agreeable the districts in which chemical works are situated. The inspectors point out that on the whole the chemical industry is in a very healthy state, despite the many difficulties it has had to meet. In their view it has been kept up to date and is in a good position to meet future competition. During 1950 the alkali inspectors paid 3970 visits to works at which industrial processes are carried on, the effects from which are liable to cause danger or nuisance in the areas in which they are situated. Although a number of infractions against the provisions of the Alkali, &c., Works Regulation Act, 1906, were recorded, there was no deliberate evasion, and prompt remedial action having been taken, it was not necessary to institute legal proceedings in any case. With the present great expansion of Britain's oil refining capacity, the problem of dealing with noxious gases has become a major one. Discussions have been held between the chief alkali inspectors and the oil interests concerned, with the result that the best means of preserving local amenities in each case have been agreed. Attention is called in the report to the likelihood of a shortage of brimstone supplies, and the inspectors state that this may well lead to difficulties in the sulphuric acid trade with consequent serious repercussions to British industry in general. Careful consideration therefore should be given to every possibility of recovery of sulphur or its compounds from materials hitherto regarded as waste. A total of 1,776,000 tons of sulphuric acid were produced in Great Britain during 1950, nearly two-thirds of which was made in contact plants, the remainder being produced in leaden chambers. A number of visits were paid to electricity generating stations, and the inspectors report that power stations in Great Britain consume annually about 30,000,000 tons of coal, and at the present moment the rate of consumption is increasing. In spite of the continual expansion that is taking place, the extent of grit emission should decrease because the greatest quantity arises from the older and more inefficient stations. The report is published by H.M. Stationery Office and costs 1s. 9d.

Railway Accident Inquiry Reports

Two reports, which were published at the end of last week, on Ministry of Transport inquiries into railway accidents, make reference to the failure of the human element. The first relates to a derailment at Greenford (Western Region) on December 20, 1950, when a Greenford-Ealing "push and pull" train, on leaving the bay platform, ran into a short spur protecting the junction ahead. The evidence at the inquiry revealed that the starting signal was at danger, tests made after the accident proving conclusively that the mechanical interlocking and electrical controls were in order. The driver had been talking to a ticket collector just before starting, and the report suggests that "his conversation must have temporarily distracted his attention so that on receiving the normal starting bell signal from the guard he automatically opened the regulator without looking at the starting signal." The inspecting officer says that, although the signal light was of low power compared with the London Transport colour lights and platform lighting, it could be clearly seen from the driver's compartment, and he does not consider there is sufficient justification for altering it. He does recommend, however, that the horizontal arms of the first two lighting poles might be turned parallel to the track so as to improve the view of the signal from the platform. The other report is concerned with a collision between a passenger train and a stationary light engine at Alloa Junction (Scottish Region) on January 10th last. The accident occurred in daylight, when visibility was good, although a heavy snowstorm had just ceased and the rails were wet. On account of the snowstorm the up distant signal had failed in the off position and the drivers of up trains were being warned verbally at the preceding signalbox at Plean that time-interval working was in operation. The signalman's instructions were transmitted by a sub-ganger. The conclusion reached by the inquiry was that, although the driver of the passenger train was cautioned at Plean and was aware that he was proceeding through the section under the time-interval system, he was travelling too fast when approaching Alloa Junction. The report remarks that "the somewhat loose method of passing messages and giving information which was employed in this particular case, gives rise to the general question of whether a more rigid and formal procedure should not be introduced when changing from absolute block to time-interval working."

LAY-OUT OF THE DAVIS DAM ON THE COLORADO RIVER



The Davis Dam Project, U.S.A.

No. I

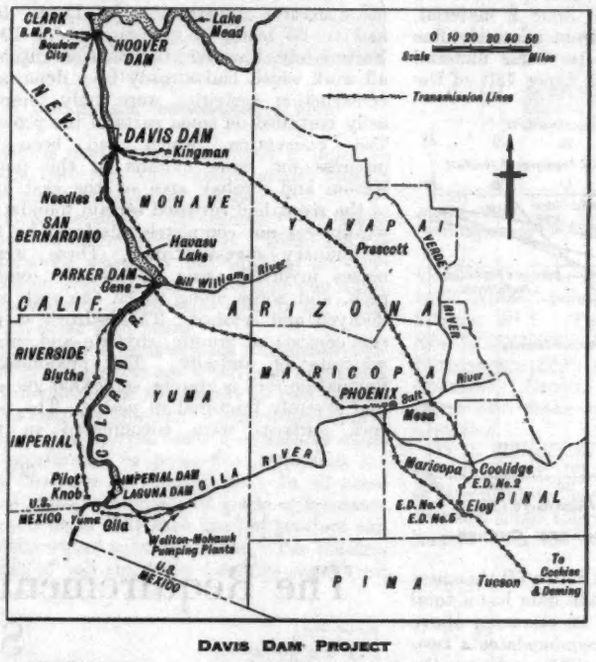
THE first of the five 45MW generators at the Davis Dam power station has been in operation since January, 1951, and all five units are scheduled to be in production this month. The power station is, at present, the fourth largest hydro-electric installation of the U.S. Bureau of Reclamation, being exceeded in capacity only by the plants at Grand Coulee dam, Hoover dam and Shasta dam. As shown in the accompanying diagram of the project, Davis dam is situated on the Colorado River in the Pyramid Canyon between the States of Nevada and Arizona, at a point about 34 miles west of Kingman, Arizona. It is 67 miles downstream from Hoover dam and 88 miles upstream from Parker dam.

The history of power development on the Lower Colorado River dates back to 1926, when a small siphon drop plant of the Yuma project began generating energy for use on the farms and communities in the project area. The first generator in the Hoover dam power station, over 300 miles upstream, went on the line to deliver power to Los Angeles in October, 1936. About 155 miles below Hoover dam, in the Parker dam power station, the first generator began operation ate [in 1942. Thus, within little more than fourteen years, three major power stations of the Bureau of Reclamation have made the Lower Colorado River the main source of power for the South-West of the United States. During the fiscal year 1950, the Hoover and Parker plants together produced 6,750,000,000kWh of electrical energy, equivalent to about 42 per cent of the power consumed in the south-west region. Originally, the Davis dam site was called "Bullshead," after a nearby rock formation which is said to resemble the head of a bull. In 1941 it was renamed in honour of the late Arthur Powell Davis, Director of Reclamation from 1914 to 1923, and one of a small group of men whose early courage, foresight and vision had led to the beginning of the Colorado River development.

The Davis dam utilises the last significant power drop on the section of the Lower Colorado River below Hoover dam. It forms another step in the stairway of dams on this river between Laguna dam, 13 miles north-east of Yuma, (Arizona) and Hoover dam, about 308 miles upstream. The Davis dam project was constructed (1) to service treaty provisions pertaining to the division of Colorado River waters between the United States and Mexico; (2) to produce hydro-electric power, and (3) to regulate irregular water releases from Lake Mead through the Hoover power plant, for irrigation use downstream. The treaty with Mexico required that the dam be built in order to regulate delivery of 1,500,000 acre-feet of water annually apportioned to that country under the treaty.

In addition to these major purposes, Davis dam will contribute to flood control, navigation improvement, and irrigation and municipal water supplies. It will further reduce the silt load of the river, and provide for waterfowl and other wildlife protection. It will also create a recreational area, as its reservoir, which has been named Lake Mohave after the local Mohave Indian tribe, will offer opportunities for fishing, boating, swimming and other sports. No new lands in the vicinity will be brought under irrigation as a result of this construction, however, and no irrigation projects in the area leading to public land settlement opportunities are contemplated at present. Except for a limited area around the dam and the adjacent Government camp, the U.S. National Park Service administers the reservoir and all public lands surrounding it, together with the public lands on both sides of the Colorado River for a distance of some 4 miles below the dam.

As early as 1902 a possible dam site in Pyramid Canyon had been investigated by reclamation engineers, but a dam at this site was not considered practicable until Hoover dam had been built upstream to control the floods of the Colorado River. Following further investigations and explorations in 1938, construction of Davis dam and its appurtenant works was authorised in April, 1941, and a contract was placed in June, 1942. Actual construction began in August, 1942. Some excavation was undertaken during the first few months, but inability to obtain materials during the war brought the work to a halt in December of the same year. In March, 1946, work was resumed by the Utah Construction Company under a new contract amounting to 21,462,505 dollars. Approximately the first year was devoted to the excavation of the diversion and forebay channel and the foundations for the spillway and intake structures. Then followed a period of intensive foundation grouting and preparations for concrete emplacement. Construction of the spillway and intake structures began in January, 1948. Construction of the main dam embankment was started in September, 1948, and completed in April, 1949. The intake and spillway structures were substantially completed in the same month. In January, 1950, the six temporary diversion openings of the spillway structure were closed with concrete stop-logs, and the first storage of water in the reservoir was begun. Placing of concrete in the six openings to complete the spillway sections was then initiated. The construction of the reinforced concrete power station structure, begun in January, 1949, was completed in the summer of 1950.



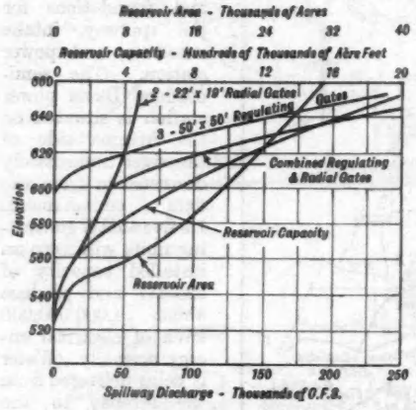
DAVIS DAM PROJECT

The Davis dam, rising to a height of about 135ft above the normal river bed, is an earth and rock-fill embankment with a concrete spillway, intake structure, and power station. It has a crest length of 1600ft, and its top width of 50ft accommodates a two-lane highway connecting the States of Nevada and Arizona. Its reservoir has a capacity of 1,820,000 acre-feet and extends the entire 67 miles upstream to the tailrace of the Hoover dam power plant. Confined for most of its length between the steep walls of Pyramid, Painted, Eldorado and Black Canyons, the lake is comparatively narrow—not more than 4 miles across at its widest point. The dam, its power plant and associated equipment and over 1000 miles of transmission lines are being constructed at a cost of approximately 114,000,000 dollars. Almost 4 million cubic yards of earth and rock fill were required to form the dam, and about 565,000 cubic yards of concrete and 10,000 tons of reinforcing steel have been placed in the spillway, power station and other structures. Over 4 million cubic yards of rock and earth were excavated to form the diversion and forebay channel and foundations for the spillway, intake structure, and power station. The semi-outdoor Davis power station is situated on the Arizona side of the river immediately downstream from the dam embankment. Its five 45MW generating units will have an installed capacity of 225MW and produce about 1,000,000,000 kWh of electrical energy annually. Water is being delivered from the forebay to the power plant through five 22ft diameter penstocks. The five 62,200 h.p. turbines are vertical-shaft, single-runner, Francis units, and have welded steel spiral casings. The rotors are 17ft in diameter, 9ft high and weigh 70 tons. They were manufactured by the Baldwin Locomotive Works under a contract involving approximately 2,300,000 dollars. The generators are three-phase, 60 c/s, vertical-shaft a.c. units, turning at a speed of about 95 r.p.m. They were manufactured by the General Electric Company of Schenectady at a cost of nearly 3,000,000 dollars. High-voltage switchyards near the power station provide the take-off point for a system of transmission lines and substations now being built to interconnect the Davis, Hoover and Parker power stations, and to extend to load centres in Central and Southern Arizona, Southern Nevada, and Southern California.

Project Design

The accompanying drawings show a general plan of the Davis dam project as a whole and various sections of the dam itself, the spillway structure, the intake structure and the power station. The dam has a height of about 135ft from stream bed to crest, with a cut-off trench of 120ft bottom width extending 65ft into the river bed. Because

of the pervious nature of the river bed materials, provision was made for an upstream apron extending a distance of about 700ft from the dam centre line and a downstream apron about 600ft in length. The dam has a crest length of 1600ft and its base covers an area of 1300 square feet, exclusive of any areas taken up by the upstream and downstream cofferdams. The maximum dam section indicates the arrangement of the main zones of embankment materials; total quantities involved were approximately 1,000,000 cubic yards of impervious material (Zone 1), 980,000 cubic yards of rock screenings (Zone 2), and 1,600,000 cubic yards of rock fill (Zone 3). Impervious material of selected sand, clay and gravel was used to fill the 50ft deep cut-off trench and extends to the top of the dam occupying the central portion. A blanket of this material covers the river bed upstream of the cofferdam. On each side of this impervious material is semi-pervious material consisting of rock screenings (less than 4in) from the diversion channel excavation. Zone 3 includes larger rock from the screening operation placed on both the upstream and downstream sides of the Zone 2 material. This rock is graduated from relatively fine material next to Zone 2 to coarse material at the outer slopes. The upper 78ft of the



STORAGE AND DISCHARGE CURVES

upstream slope is covered with a 6ft thickness of riprap. The crest of the dam has a total width of 50ft and is at an elevation above sea level of 655ft. It accommodates a two-lane highway 40ft in width and, on the upstream side, a pedestrians' pavement approximately 4ft wide.

The forebay and diversion channels around the Arizona abutment of the dam range in width from 50ft to 200ft and have a combined length of about two-thirds of a mile. A bridge comprising two 210ft plate girder spans, a reinforced concrete deck and a central reinforced concrete pier, was designed to carry the highway crossing the crest of Davis dam over the forebay channel.

The spillway has a crest elevation of 597ft and, at a reservoir elevation of 647ft, a total capacity of 192,000 cusecs. It has an ogee weir, which is surmounted by three fixed-wheel regulating gates, each 50ft by 50ft in size. The outlet works have a sill elevation of 542ft, and, at a reservoir elevation of 647ft, a total capacity of 60,000 cusecs. There are two openings, situated on either side of the spillway, and controlled by high-head radial gates, each 22ft by 19ft in size. The capacities of the spillway and the outlet works have been plotted on the accompanying graph.

Trash-racks are provided in front of the five penstock entrances along the forebay wall of the intake structure. The intake gates are moved by means of a 110-ton gantry crane traversing along the deck of the intake structure. The five penstocks are spaced at a pitch of 60ft and curve through an angle of approximately 28 deg. in the horizontal plane. The penstocks are 22ft in diameter and are of welded construction. The elevation of the penstock centre at exit and of the turbine spiral casings is 513ft, so that, at a reservoir elevation of 647ft, there is a drop available of 134ft. The elevation at the bottom of the draft tube gate is 475ft 3in.

The power station is a reinforced concrete structure of semi-outdoor design with the tops of the generators extending through the roof. It is situated between the intake structure and the original river channel, running almost parallel to the latter. Each of the five Francis vertical-shaft, single-runner turbines is rated at 62,200 h.p., and each generator will produce 45,000kW at a speed of about 95 r.p.m. The roof of the power station is traversed by a gantry crane of 300-ton capacity.

Following the discovery of certain foundation weaknesses, several changes in the design of structures appertaining to Davis dam had to be made in the summer of 1947. Fortunately, however, the revisions utilised all work which had already been done, and construction activities were only temporarily curtailed on some parts of the project. The excavation, which had been in progress for some months in the power station and forebay area on the east side of the river, had revealed certain foundation weaknesses not completely disclosed by the preliminary investigations. These weaknesses involved areas of severely jointed rock, and zones along which the rock was decayed and crushed. The bedrock at the site consists of granite, rhyolite and minor amounts of andesite. The predominant foundation rock is granite, somewhat gneissic and severely fractured in places. The bedrock surfaces were encountered in the excavations at predicted levels, but detailed studies conducted concurrently with the excavations revealed that, although the degree of weathering decreased with depth, this was not true of the jointing and fracturing. The broken and rather weakened condition of the rock had been known from the beginning, but two sub-parallel zones in which the fracturing was especially severe had proved to be more continuous than had been anticipated. One of these zones was exposed in the power stations excavation. Both zones dipped diagonally away from the river in a south-easterly direction, passing under the intake structure, the power station and the spillway. The rock overlying the zones was considerably less fractured and of better quality.

Upon the recommendations of a consulting board of engineers and geologists, the intake structure was shifted to remove the north end from its former position, at which it would have been underlain by the weak zone at a shallow depth. In the new position the uppermost crushed zone lies at a greater depth beneath the floor of the excavation, and a correspondingly greater thickness of sound rock is being utilised in the foundation of the structure than would have been possible in the original position. The power station was moved slightly upstream to facilitate the entrance of the five 22ft diameter penstocks leading from the intake structure in its new position. The subgrade for the spillway structure was changed to a horizontal plane and the base of the structure was thickened to about 30ft. A slab footing was extended upstream by a distance of about 50ft from the upstream face to secure a firm anchorage to bedrock of the spillway structure. Finally, the switchyard, originally situated on the west bank of the forebay channel, was moved to an area about 1000ft east of the channel. This change was made necessary by a flattening of the side slopes of the forebay channel from $\frac{1}{4}$: 1 to 1 : 1.

(To be continued)

The Requirements of a Good Tolerance System

By H. G. CONWAY, M.I.Mech.E.

Introduction

A TOLERANCE system is an essential requirement for the production of drawings, which must be suitable for modern manufacturing practices. Tables and handbooks of limits and fits are as important to the designer as the soundness of the theoretical and practical basis on which the system is constructed is to the production engineer and inspector.

Next only in importance to national standards for screw threads, therefore, are national tolerance standards, in this country the British standard for limits and fits (B.S. 164), supplemented by the very widely used, although obsolescent, Newall system. The publication of any new British standard would therefore be a matter of considerable importance to all mechanical engineers, whether designers or production men.

The original publication of B.S. 164 was made in 1924 and was the result of a certain amount of clarification and formation of opinion during the 1914–18 war. Revision following the recent war is now due and it is to be hoped that a new standard will be available in a year or two.

Existing Standards

Experience with B.S. 164:1924 indicates that it is a satisfactory standard in many respects, its chief fault being that although four grades of hole are listed (suitable for various manufacturing processes), only one grade of shaft is tabled in each fit and that corresponds to the closest hole. In practice this means that the shaft tolerances are of the kind normally requiring grinding (e.g., 0·0006in on a 1·25in diameter shaft) and are certainly unsuitable for normal capstan work. What many firms have done in their own local practice is naturally to increase the shaft tolerances, leaving minimum clearances, and thus the fits, unaltered.

However, in preparing a new standard practice in other countries must be considered as well as experience with the old standard. It happens that America is little better off than Britain, having issued only one standard (in 1925) and also having

had its revision in hand for some time, without, so far, published result. In 1942, however, the American Society of Mechanical Engineers translated and published a version of the I.S.A. system. This system, published by the now defunct International Standards Association in Geneva, is the most recent and certainly the most thorough of all systems and must of necessity be the basis either directly of a new standard or, where it may considered defective, of alteration or amendment. The I.S.A. system was published in various stages in the period 1932–42, and was the result of a great deal of work in various countries, the chief of which were Germany, France and Sweden. It relates naturally to the metric system; apart from the American translation referred to above (which contained various errors), an accurately computed series of inch tables has been published in this country.*

The Requirements of a Good Tolerance System

In order to prepare the ground for consideration of any new standard, the basic requirements of a good tolerance system can be briefly restated.

(*a*) It is necessary to define what limits quoted in the system's tables refer to and what axial, ovality, and straightness, errors are tolerable. The usual definition is that any errors must lie within the envelopes or

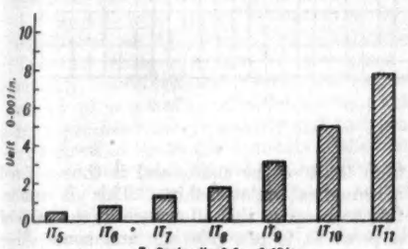


Fig. 1—Relative Magnitude of I.S.A. Fit Tolerances

surfaces defined by the limits; in the particular case of a hole, for example, the maximum limit defines the greatest diameter at any point and the minimum limit the diameter of the inscribed cylinder, any variation of form within this limitation being permissible.

(*b*) It may be necessary to define the unit of measurement (or how long is the inch), although in Britain this is implicit. It is desirable, however, to specify that the dimensions of any limits are those as are apparent when the component is measured by the type of gauge specified in the standard. When dealing with close tolerance this can be more important than might at first be believed, because the difference in size measured by various systems of measurement, is not inappreciable, due, for example, to surface indentation by the measuring device.

(*c*) Because of the above two factors it is essential to specify a system of gauging so that the dimensional meaning of limits cannot be disputed. This practice, although rare on any tolerance system other than the I.S.A., is normal practice in Britain and U.S.A. for screw thread standards for the same reasons as have been mentioned. It is particularly important to specify the gauging load or load under which the gauge must pass, as errors due to even light forcing are appreciable. Gauge tolerances *must* be included.

(*d*) A series of diameter steps must be worked out. The technical requirement here is not critical provided that the steps are well graded, so that theory and practical compromise do not fall too wide apart. In this connection press fits are more critical than normal clearance fits and require smaller steps. The use of common sizes for the extremities of the steps may not be good practice since commonly used sizes should preferably fall in the middle of the steps.

(*e*) The system of tolerances themselves must be worked out on some basis. This

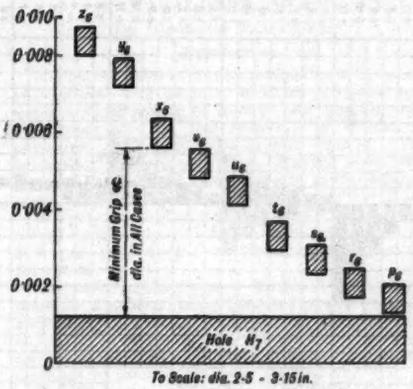


Fig. 2—I.S.A. Interference Fits

matter is dealt with below but it must be stated here that this system should include tolerances suitable for gauges.

(*f*) A system of "allowances" or "deviations" must be worked out. These are the dimensions which by the addition of tolerances on hole and shaft determine the limits themselves of a particular class of fit. This is also dealt with below.

(*g*) Finally a limit system is completed by tabling for general use a series of tolerances and deviations or allowances to give various fits as may be required. An important requirement of the system must be a suitable range of interference or press fits, transition fits and clearance or running fits. In all cases there must be a choice of grade of tolerance in each fit so that each kind of product can use the widest tolerable limits. The requirements of ball and roller bearings should not

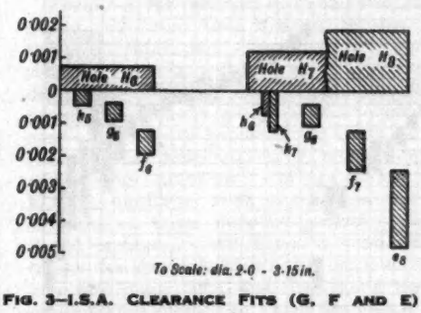


Fig. 3—I.S.A. Clearance Fits (G, F and E)

be overlooked as they make use of some of the most important of fits.

(*h*) A subsidiary requirement of a good limit system, which will obviously be basically of the unilateral hole type, is the tabulation of oversize holes for special purposes. The I.S.A. system goes even further and tabulates a full range of holes and shaft on both unilateral hole and unilateral shaft basis, the latter recommended for special use only.

Tolerance Determination

It has become normal practice in determining a tolerance system to calculate the tolerance applicable to a particular diameter from a formula involving the diameter to some fractional power, such as the square or cube root. This is because more tolerance is necessary as diameter increases for equal "manufacturing difficulty." Although the original B.S. 164 : 1924 system referred to a formula involving $\sqrt{D}$, this was used with the diameter of the end of the diameter step in question instead of the mean (strictly the geometric mean) of the diameter step.

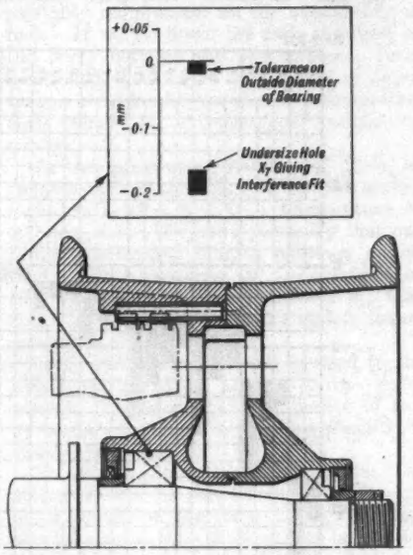
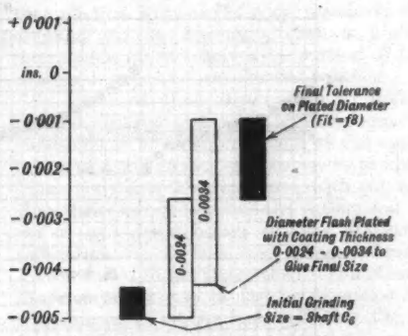


Fig. 4—The Use of Unusual Hole Limits on Bearing in Magnesium Alloy Wheel

Using the latter it was pointed out in the book already referred to that the formula became $D^{4/9}$. The I.S.A. and American standards, however, use a formula with a lower power ($D^{1/3}$), involving less change with diameter; British Whitworth thread tolerances also make use of the cube root of diameter.

It is difficult to be scientifically critical on this matter. The lower power of diameter is beneficial, in particular, in preventing extremely small tolerance on the smaller diameters; on the whole, it would be more



Note that the maximum plating thickness (diametral) is the difference between the deviations or allowances of the two shaft fits; and that the tolerance on plating is the difference of tolerance of the two fits.

(To scale, diameter 1·75in)

Fig. 5—The Use of Undersize Shaft Limits on Plated Parts

logical and consistent to use ($D^{1/3}$) in place of ($D^{4/9}$).

Having chosen a basis for a single range of tolerances in various diameters, a series of multiples must be worked out. B.S. 164 used multiples of 2, the magnitudes of holes *B*, *U*, *V*, *W*, being in the ratio 1, 2, 4, 8. This graduation is considered too coarse, a factor of about 1·5 being more suitable for production requirements. A convenient basis, as used in the I.S.A. system, is the 5-series Pre-

* "Engineering Tolerances," by H. G. Conway, Pitman, 1948.

ferred Numbers based on the 5th root of 10 (1, 1·6, 2·5, 4, 6·3, 10).

Fig. 1 illustrates the relative magnitudes of those tolerances in the I.S.A. system that are intended for fits.

Having determined a calculated series of tolerances, recourse must be made to some degree of rounding off. There are two possibilities :—

(*a*) The calculated tolerances can be rounded off to the smallest convenient values which are available commercially on slip blocks (0·00005in or 1 micron). Only when the magnitude of the tolerance becomes large would coarser rounding off be made (e.g., to 0·00005in up to 0·0005in, 0·0001in up to 0·001in, and so on) ; or

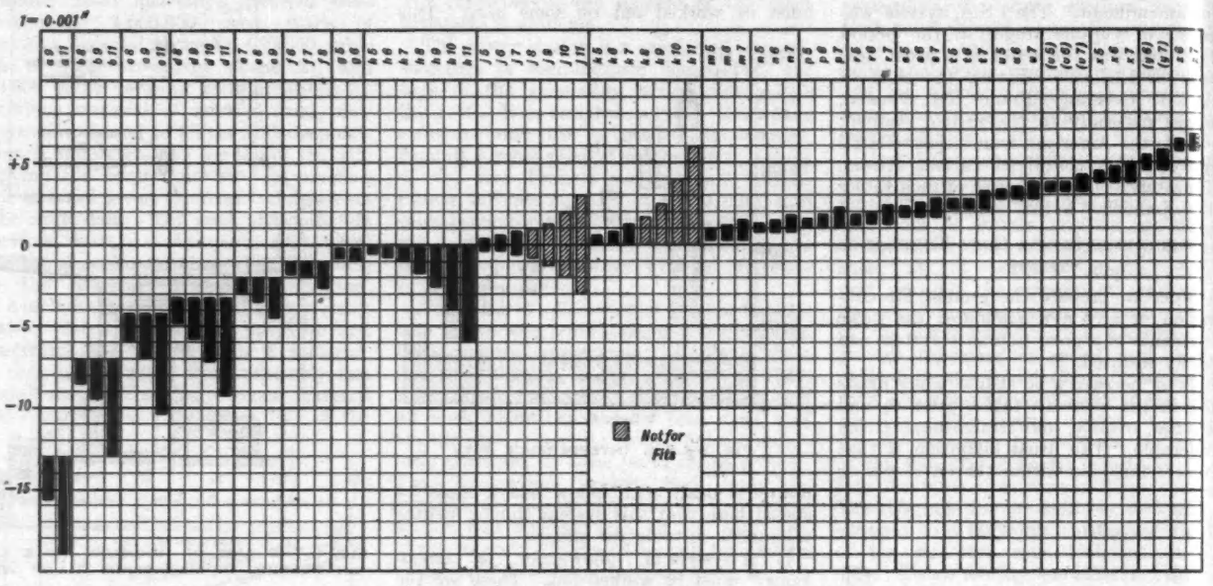
(*b*) The calculated figures can be rounded off to a series of standardised tolerances, such as a preferred number series, so that only a limited number of different tolerance magnitudes are used.

To adopt the second practice would appear from every point of view to be wrong and illogical. The following reasons will be obvious on reflection :—

(i) The rounding off of tolerance to large values, such as 0·0006in, 0·0008in, 0·001in, &c., is not at all helpful in simplifying the final drawing dimension, unless the latter happens to be a convenient decimal size, e.g., $^{11}/_{32}$in—0·0006=0·34375—0·0006 =0·34315, which is still to five decimal places.

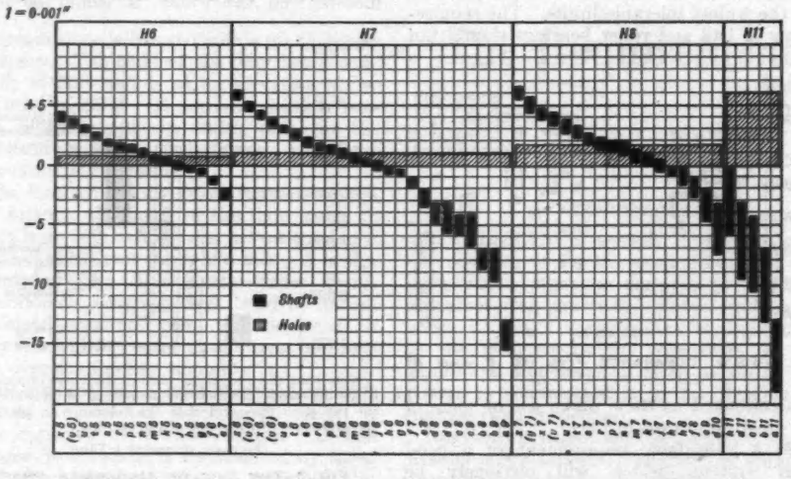
(ii) If theory requires a tolerance of 0·0011in and this is rounded off to 0·001in, what happens is that the manufacturing tolerance is reduced by 10 per cent. Although the odd 0·0001in seems a small and insignificant amount (and probably is from the functional point of view) its presence will ultimately be felt when large numbers of components have been made. Anyone with an elementary knowledge of quality control will appreciate this point.

(iii) It is no more easy nor difficult to measure 1·001in than 1·0011in. Tolerance systems are intended to be used with gauges and again no virtue exists in setting the gauge to a rounded-off value. In fact, gauges have to be set or measured to special limits involving wear allowances, &c., expressed, of necessity, in very fine tolerances.



(To scale, diameter 1·6–2·0in)

FIG. 6—I.S.A. SHAFT LIMITS



(To scale, diameter 1·6–2·0in)

FIG. 7—RECOMMENDED SELECTION OF I.S.A. FITS FOR GENERAL ENGINEERING REQUIREMENTS

DETERMINATION OF ALLOWANCES OR DEVIATIONS

It is the allowances or deviations which enable the table of tolerances to be made into a system of limits. The British use of the word "allowance" is unfortunate ; it has sprung into use from the common practice of reducing the size of a shaft so that it is a clearance fit in a unilateral hole. This reduction in diameter has always been called in this country "an allowance"—presumably a "working allowance." It is now commonly defined as the difference in diameter between the low limit of the hole and the high limit of the shaft, and is thus a fixed arithmetical relationship. This is unfortunate because this allowance in the case of a press fit is not relevant and some other term must be used for the important dimension—the minimum grip or the difference between shaft low limit and hole high limit.

It is important to distinguish clearly between the different demands of the three types of fit—clearance, press and transition. Although it might eventually be possible for a tolerance system to be based entirely upon mean fits, modern production methods are such that the minimum must always be considered because it will in fact more or less frequently occur.

The significant factor in a clearance fit is the deviation giving the minimum clearance. A proper system of deviations must be worked out, giving a range of minimum clearances suitable for all requirements ; to each can be applied one or more grades of tolerance to give the final shaft limits. Practice with different types of clearance shaft varies so much that it is scarcely possible to determine clearance deviations on any sound mathematical basis, and what the engineer requires is simply a wide enough choice in any diameter range.

In the case, however, of press fits the most important factors are not the mean grip, but the minimum and maximum. The minimum grip determines whether the press fit is always going to be tight enough and the maximum grip determines whether permanent damage to the part during assembly may occur.

For a variety of good reasons the unilateral hole basis has been chosen for all modern tolerance systems, but the fundamental deviation of a press fit is not strictly speaking related to zero, but to the upper limit of the hole. A correct system would therefore specify the lower limit of the shaft as the sum of the tolerance on the hole and an

increment determined mathematically.

In the assembly of parts under the elastic strains which occur with most press or shrink fits, the grip is proportional to the relative extension or the interference per inch of diameter. It is certainly not proportional to any fractional power of the diameter. In a practical system, however, it may only be possible to make the minimum grip proportional to the diameter; the maximum grip will be proportional to the diameter plus the sum of two tolerance factors which are themselves proportional to lower powers of the diameter (e.g., $aD+bD^{1/3}$). Fig. 2 illustrates how the I.S.A. system treats this question.

In the case of transition fits it is obviously not possible to determine any rational mathematical basis for determining any particular fit. All that can be done is to select a few suitable fits for the shaft which, when mated with appropriate holes, will cover the gap between clearance and press fits. The mean fits in this case will be evenly graded.

It must be stated that even the most careful consideration of the I.S.A. system has failed to discover any serious defect or, for that matter, any minor one except possibly that some engineers might feel that there was a need for two shaft fits between "*g*" and "*e*" instead of the single fit "*f*," which is available at present (see Fig. 3). The various English-speaking critics who condemn the I.S.A. system are never specific in their criticisms except to state that it is considered to be much too complicated. The fact that a system of tolerances is broadly conceived and covers the requirements of a variety of different industries from precision gauge making and ball bearings down to the rough demands of the black nut and bolt trade should not be taken as a basis for criticism, because it is up to individual engineering industries to select what they require from the standard and simplify it for local use. This point is very clearly brought out in the I.S.A. Standard and there was never any intention that many of the fits should be used except in exceptional circumstances. It is a matter for criticism that in Britain no tolerance system has ever listed ball bearing fits, and that gauge tolerances were not published until 1941.

The author can call to mind several occasions when he has been involved in using one or two of the more unusual I.S.A. fits which are not to be found in other standards. Surely the presence of available fits, which the following examples will illustrate, is an advantage, not a matter for criticism.

In the fitting of a tapered roller bearing into a magnesium aeroplane wheel, a fit of very considerable interference is required owing to the high elasticity of the light alloy. One of the extreme undersize holes in the I.S.A. Standard has been used with great success (Fig. 4).

In the selection of limits to grind a shaft so that it finishes up as a standard size after hard chromium-plating, a fit with considerable clearance, but small tolerance, is found useful. Fig. 5 illustrates an example using I.S.A. limits.

Fig. 6 illustrates the full range of I.S.A. shafts which are listed, while the general requirements of ordinary engineering are covered by those shown in Fig. 7.

Engineers are entitled to national standards based on quality without regard to originality. The fact that a tolerance system originated outside this country is no reason for not adopting it here. The I.S.A. system is the most modern and comprehensive of known systems, and it is difficult to find a reason why it should not replace the admittedly obsolete B.S. 164 system.

International Conference of Naval Architects and Marine Engineers

No. III—(*Continued from page 47, July 13th*)

THE opening paper on Thursday morning, June 28th, was:

CHARACTERISTICS AND DEVELOPMENT OF NAVAL FUEL OILS

By Monsieur Blanchier

Synopsis

The paper reviews fuel characteristics with regard to utilisation and discusses the effect of sulphur and sodium, the pumping of fuels at low temperatures, the importance of the breaking of emulsions, explosive vapours and the asphalt content. The increasing dependence upon Middle East fuel supplies has resulted in an increase in the sulphur content from 0·5 per cent before World War No. I to 3·5 per cent to-day, and the paper describes tests using such fuel, the results indicating that that 3·5 per cent is the maximum which can be tolerated.

Sea water in the tanks is the chief cause of the presence of sodium, but refineries also add lime and sodium and a reasonable ash content is one part per thousand, as sodium causes deposit on boiler tubes. Causes of sea water contamination are listed and methods of de-emulsification referred to.

Middle East fuels having a paraffin base are affected by cold, the crystallisation of the paraffin below 50 deg. Cent. causing pumping troubles, and a method of determining the gelling point is of importance. Heating systems are discussed and also the need to prevent excessive coking. Stability and compatibility of fuels are mentioned, tests for evaluating stability described, and also the possibilities of flocculation when two stable fuels are mixed.

Heavy fuels and gas turbines are briefly considered, and the paper concludes with notes upon experiments using boiler fuel in diesel engines. The use of vegetable oils is mentioned, together with the fact of their ignition delay and the need to increase the load on the needle springs in the mechanical system and the air pressure for the air-blast injection system.

Discussion

Commander (E) L. E. S. H. Le Bailly, R.N. (Great Britain): During the last two years I have been working with Monsieur Blanchier, trying to ensure that the fuels and lubricants used by the Western European allies are interchangeable and to a standard specification.

Thanks to the foresight of Lord Fisher and others, the Royal Navy were the pioneers in the use of liquid fuel. Since then the world situation has changed, and any navy which did not give serious consideration to fuel problems would be guilty of short-sightedness. Some of our problems are the same as those of the merchant navy, being purely combustion problems; others, such as handling problems, both at sea from ship to ship and on board ship, are possibly purely naval problems. We have to plan ships to-day for the fuels which will be in supply in a few years' time, and that is not made easier by the speed with which the petroleum industry moves, as it is most relentless in discarding out-of-date technique and processes.

The British Admiralty have turned to the British petroleum industry with its problems, and the Admiralty Oil Quality Committee includes representatives of the industry and independent petroleum technologists. I disagree with the author on the importance which he attributes to the effect of sulphur on personnel. My experience suggests that if the ventilation systems of ships are such or if the enemy damages a ship so much that funnel gases get into the machinery spaces, 1 or 2 per cent of sulphur does not make much difference.

Another matter which should be brought into the paper is the effect of the compatibility requirement on the availability of fuels. If we tie down the fuels required in the Navy between the two reference fuels mentioned there is on either side of those fuels a considerable margin of incompatible fuels which in an emergency might be needed.

On the question of stability of fuels, in connection with the N.B.T.L. test the author mentions testing fuel at a temperature of 200 deg. Fah. We heard yesterday that our future combustion designs envisage a viscosity which requires a temperature of 220 deg. to 230 deg. Fah. to achieve it; that means that the test does not simulate future conditions.

Lastly, the users will look forward to the petroleum industry's answer to the statement in the paper, that the quality of fuel by reason of present-day refining practice, is steadily deteriorating.

Mr. H. F. Jones (Great Britain): The author speaks of restrictive limits for the water content of the fuel. I believe all fuel suppliers agree that there should be restrictions on the water content of the fuel, but that the overall aim should be no sea water in the fuel. However, that purpose is not achieved, nor are the restrictive limits of much use so long as ballasting with sea water or displacement of the fuel oil by sea water continue.

In connection with sulphur content, the author refers to trouble envisaged due to corrosion of the boiler drums, of the boiler tubes and also of the platework; but troubles in the low-temperature zones, such as the preheaters and economisers, are not specifically mentioned. More information on that would be welcome. The author speaks of two-thirds of the ash from the fuel being sulphate of soda, and I think he is assuming that all that sulphate of soda reacts on the alumina in the fireclay. That is highly improbable, particularly as a portion of the sodium is deposited on the water tubes.

It is stated that experiments to find a method suitable for the breaking up of emulsions on an industrial scale by the application of a commercial surface-active product (Sinnopon) have been crowned with success. Has their use facilitated the separation of water by centrifuging, or has it made separation by centrifuging more difficult?

It is stated in the paper that "The general heating system must be capable of raising the temperature of all the fuel to 30 deg. Cent." (about 86 deg. Fah.) "even under the most severe temperature conditions, which in Europe has been fixed as 1 deg. Cent. for sea water and 8 deg. Cent. for the atmosphere." One would expect that the atmospheric temperature under the most severe conditions would be below that of the sea water, and the figure for the atmospheric temperature should be —8 deg. Cent.

In the final section of the paper, dealing with boiler fuels in diesel engines, the author states that whenever the temperature at any part of the engine which may be in contact with the combustion gases falls below the dewpoint (about 175 deg. Cent.) sulphuric acid condensation with a solution of sulphur dioxide may take place. He points out that the temperature in a crankcase is obviously

much lower. I query 175 deg. Cent. as the dewpoint of sulphuric acid, and point out that the crankcase derives some benefit from a film of oil protecting the stationary and working parts from attack by sulphur.

Mr. H. T. Lorne (Great Britain): The paper appears to emphasise the bad points of Middle East fuel oil, but there are instances where they are known to be very satisfactory. It is gratifying to note in the paper that 3½ per cent of sulphur is tolerable; I suggest that a good deal more is tolerable, and that that figure, if the French Navy persist in their tests, will be increased to 4½ per cent. Later in the paper it is suggested that no more than 2 per cent should be allowed in fuels for diesel engines, and I would recommend Monsieur Blanchier to refer to Mr. Lamb's paper, presented last year to the Institute of Marine Engineers, from which he will find that fuels of far greater sulphur content have been used with complete satisfaction.

With the increasing loads on boilers the problem of deposits may arise in different form in the future from that of the past. Suppliers are well aware that ash in the fuel should be avoided, and they take all possible precautions to ensure that contamination does not take place. But it is useless to do that if fuel is burned with sea water, and the sea water contamination should be restricted to a minimum.

In connection with cold test properties, emphasis is placed on measuring the highest pour point that can be obtained for a fuel. The emphasis is wrongly placed, for study shows that proper heat-treatment improves the pumpability of fuels and also that the pour point may not be an indication of the pumpability or performance of the fuel. In most cases with the waxy, asphaltic types of fuel oil obtained from Middle East crudes, the pumpable limit has been 20 deg. below the apparent pour point. Rather than spend time determining the highest pour point more effort should be applied to handling it under normal conditions.

In the past some processes have caused fuel deterioration, but it does not hold true to-day. It is only certain types of cracking processes which cause deterioration of fuel oils, and I have reason to believe that other types improve them. The author has quoted vanadium contents of up to 0·05 per cent in heavy fuel oils from Iraq. But Iraq fuel oil will have a vanadium content of no more than about 40 parts per million, so the figure of 0·05 per cent must be a misprint.

Mr. C. W. G. Martin (Great Britain): There has been some misconception about deterioration in quality; it cropped up in an earlier paper by Admiral Gray and Mr. Kilner before the Institute of Marine Engineers. Admiralty fuels have become higher in viscosity, and I think the navies are prepared to accept fuels of higher viscosity. By and large, fuels have not deteriorated; in many cases the major companies are quoting specifications superior to those they quoted before the war.

Although sulphur is referred to in the paper as an impurity, it is not so. Sulphur occurs not only in gas oil, but in the heavier fuels as well. It can be taken out of oils, but it is not possible economically to take it out of residual fuels.

Some work at Thornton Research Station has given results in which there is no evidence to suggest that conditions may worsen comparatively suddenly with sulphur contents above 3½ per cent; and I mention that work to follow up the remark by an earlier speaker that there is no particular magic in the value of 3½ per cent as the sulphur limit.

I was concerned by the attempt to restrict the sulphur content of oils used in diesel engines to 2 per cent. It is illogical that fuels should have 3½ per cent of sulphur when used in a boiler, and only 2 per cent in a diesel engine. There are thirty-six motorships in the Anglo-Saxon Company's fleet running on fuel oil with a sulphur content of between 2 and 3 per cent, without any adverse effect as compared with ships in the same fleet running on marine diesel fuel.

There is something to be said for the ash limitation of 0·1 per cent in the fuel for warships, but the author is not correct when he refers to two-thirds of the ash being sodium sulphate. I doubt whether an ash content of 0·1 per cent is equivalent to sea water contamination of 2 per cent, and whether the amount of natural ash present in any fuel oil could have the same deleterious effects on the refractories as has sea water.

"Teepol" as a means of separating water from fuel oil is effective in a critical concentration, but beyond that it may do more harm than good.

The author seems concerned that the asphalt content is not included in fuel oil specifications. That omission is understandable, because the asphalt determination is a laboratory solubility test and has little to do with how the fuel burns. Asphaltic bitumen burns perfectly well if you have the proper equipment, and we can dispense with the asphalt figure in the specification.

Mr. H. Gamlen (Great Britain): Sulphur in fuel oil, or in solid fuels, is undesirable in either a boiler or a diesel engine, and especially in steel and glass processing furnaces, but the merchant navy must take such fuels as are available, consistent with the economics of fuel oil production. Even the U.S. Navy, which has special Navy fuel, has not eliminated problems of sulphur, combustion deposits or sludge. The problem of de-emulsifying without danger of re-emulsifying is now being handled to the complete satisfaction of the user. In the United States and on the Continent many hundreds of ships are having their fuels treated at very low cost. According to the majority of fuel analysis certificates, sulphur is listed in its metallic form, and this raises a question, for sulphur can hardly exist in its metallic form in fuel oil, it being present generally combined with some other metal.

It has been shown in many papers that the dewpoint has quite a long range of temperature, depending on the amount of water present, and has not a fixed temperature. During the period of starting a boiler from cold the amount of sweating and deposition of sulphurous and/or sulphuric acid is dependent on the existing circumstances. The formation of sulphur compounds for the most part takes place at quite normal temperatures, while for superheater tubes a different set of circumstances prevails, so that the sulphates can become plastic. As the spaces between tubes become closed, impedance is offered to the flow of gases out of the boiler, to set up a new order of circumstances quite unrelated to the sulphur compounds. If the gases cannot get out of the boiler, a reducing atmosphere, high in CO_2, is created to cause a chain of reactions. We have many records of samples of fuel oil taken from ships' tanks where the combined sulphur and sulphates averaged 8·8 per cent for a whole year, yet these undesirables have been and are being successfully controlled by safe and simple chemical means.

The vanadium content of fuels is undoubtedly an excellent catalyst. Among the thousands of samples of deposits of combustion analysed over the past twenty years, vanadium has been present quite frequently in amount from 0·2 to 8 per cent, in the form of V_2O_5. Sulphates are usually water soluble, and it is possible that the water content of fuel serves the purpose of dissolving soluble sulphates, provided, of course, that precipitated water is separated chemically from the fuel before it enters the boiler furnace or diesel engine.

The second paper read on Thursday morning was:

SHIP MOTIONS

By JOHN C. NIEDERMAIR

SYNOPSIS

Recent knowledge gained concerning the six oscillatory motions of ships at sea is reviewed. These motions are grouped under the following headings: reduction of speed in waves, pitch, surge, heave, roll and directional stability. New experimental data are presented in tabular and graphical form, for the first three groups, and are correlated with recent theoretical findings.

Model tests have shown that maximum speed reduction occurs when the ratio of wave length to ship length is about one and not at the point of maximum pitching amplitude. The conclusions about pitching motion include the fact that maximum pitching amplitudes in regular steep waves are more a function of the speed of the ship and the length of the wave than the individuality of the ship, while calculations for natural pitching period should make allowance for the added inertia of entrained water.

Generally the model experiments and theory agree, but the extreme test conditions and wave-exciting forces wiped out differences in hull form. For strength purposes a wave height of $1 \cdot 1 \sqrt{}$ wave length is satisfactory, but for motion studies a height of $0 \cdot 55 \sqrt{}$ wave length is suggested for prediction of ship performance from model tests. A standard sea condition for all rough water model testing is proposed. The difficulties of full-scale testing are discussed and the need for both new facilities and more theoretical work is emphasised.

DISCUSSION

Mr. R. W. L. Gawn (Great Britain): There is much to be said for investigating ship oscillations by small models, and some experiments of the same character were carried out at Haslar and described in a paper by R. E. Froude in 1905. The early models then tested were about the same length as those of Mr. Niedermair, but the later models were about 7ft long, experience having shown that larger models could safely be used. Ship oscillations frequently build up and die down in a cycle of phases, and in order to represent the true motion we must have a definite number of cycles completed during an experiment. The length of the tank mentioned in the paper is only eleven times the length of the model, and the number of waves which the model meets is limited accordingly. This applies to the longer waves, which are of the greater interest because of their greater motion. Perhaps the author would give his views as to any reaction on the results.

The experiments were made with a constant towing pull applied to the model, but at Haslar the model is arranged to move ahead on to the waves at a series of constant speeds of advance. The two methods are appropriate to the equipment in the respective tanks, but a constant pull is perhaps a closer approach to ship conditions. With contant towing pull the speed of advance varies, and this departure from steady conditions is a disadvantage from the scientific point of view of comparing with theory. I have sought to see how closely the results of the two methods approach, and there is considerable measure of agreement.

The author states that, in spite of wide hull differences between individual models, all the models behaved substantially alike, and I take it that that means they behaved substantially alike as regards amplitude and periods of motion, because it does seem to be a fact that quite large changes in hull form

are insignificant as compared with changes in the distribution of loading, which affect the radius of gyration and therefore the period.

The author includes in the definition of natural pitching period the virtual mass. He says the matter is controversial, and I think that is an understatement, because he assumes that the inertia coefficients can be calculated from the data for deeply submerged bodies. The inertia coefficient of a floating body will be vastly different from that of a submerged body, and no consideration has been given to the influence of damping or speed on the period. Perhaps the author will state whether any results are available for the still water pitching period of the models to determine the influence of the various factors. The pitching period of the ship as distinct from the period of forced oscillation is also subject to variation with the size of wave which the ship meets and again by the size of the waves created by the speed of the ship. I suggest that we should simplify the basic period by including only one factor, namely, virtual mass, and neglect all other factors, and plead that the natural period be calculated from the fore-and-aft radius of gyration and longitudinal metacentric height.

Professor A. M. Robb (Great Britain): I suggest that the presentation of the results has been considerably affected by the choice of an unpopular parameter, particularly the graph dealing with the maximum pitching amplitude/maximum wave slope for individual models in seas of varying length. There is no such direct relation between maximum amplitude and maximum wave slope. In the case of rolling we do take the maximum wave slope as a parameter, assuming that the breadth of the ship is small in relation to the length of the wave. Here we have a length of ship which ranges from a major fraction of the wave length to a multiple of the wavelength, and in that condition maximum wave slope ceases to have any direct significance, while in rolling the maximum wave slope is also the maximum statical angle of equilibrium, and that is the basic quantity. In considering pitching we should also take the maximum angle of statical equilibrium, so that instead of the angle decreasing with increase of length of wave it increases. Using that more rational parameter, I suggest you will get a totally different result in the graph and a more rational plotting.

Dr. F. H. Todd (U.S.A.): The problem of ship motions is intimately bound up with the seaworthiness of ships. The progress of knowledge on this subject has languished in the past because there has never been an adequate theory of the basic elements with which we can interpret the results we have obtained either from models or ships and guide us in planning our experimental research. Seaworthiness has recently been given high priority in the work of the David Taylor Model Basin at Washington, and a recent paper by Weinblum and St. Denis, of the staff of the Basin, will become a guide to the subject of seaworthiness. Mr. Niedermair now gives us results of model experiments in waves which, as he points out, show general agreement with the theoretical work done by Weinblum and St. Denis.

The paper brings out the effect of freeboard at the fore end of a ship. Some model experiments which I carried out with large trawler forms showed the immense value of freeboard forward in ensuring good sea performance. Those experiments also showed that with the relatively high speed/length ratio of these trawlers one could adopt fine angles of entrance and ensure good sea speed qualities, and dryness of decks. There was opposition by ship captains and owners, who were certain that the fining of the fore end would make a bad sea boat, which would not rise to the waves. They were proved to be wrong, and these ships proved to be sea-kindly.

Model experiments on rough water performance have been in progress for a number of years, but the only tests possible have been those in head-on and following seas, conditions seldom met in practice. When crossing the Atlantic it always seems that lumps of water are being thrown about, rather than a particular wave system, and I endorse the author's proposal for new facilities in which models can be run under all conditions of waves.

The models used are quite small, 4ft to 5ft long, and the forces dealt with are mostly inertia forces involving pressure changes, while the viscous forces are much less important. It is believed that with suitable care and precautions the use of small models will give reliable comparative results. The application of the results to predict actual ship performance is another question. We need some fundamental work on ship model correlation, and we have recently sent two parties from the Model Basin across the Atlantic in winter, and a party is spending a month at sea on a coastguard ship. The ships were not completely instrumented, but we have obtained powers and speeds, pitching and heeling records and accelerations.

Seaworthiness is a live subject in the United States, and the American Tank Conference has an active committee working on it, which has agreed to systematic experiments on merchant ship forms of block coefficients varying from 0·60 to 0·80. The Hydromechanics Sub-Committee of the Society of Naval Architects has endorsed the suggestion, and we are setting up a scheme whereby the different model basins will each take one of the parent forms and make changes in such factors as freeboard, flare above water line, types of sections forward, and so on. Similar experiments are being undertaken at the Taylor Model Basin with some simplified mathematical forms in order to determine the various inertia and damping coefficients to assist Weinblum and St. Denis in the further development of their theoretical work.

Mr. A. J. Williams (Great Britain): We have in recent years taken a considerable interest in ship motions in connection with the problem of armament control, and have carried out a number of sea trials. The problem of weapon control is concerned particularly with the velocities and accelerations of angular motions. The curves given in one graph show the variation of a measure of the amplitude of pitching motion with wave length, whilst another graph indicates that the period of motion is equal to the period of encounter. From this information curves have been plotted showing the variation of angular velocity and acceleration with wave length. The curves I show indicate how this has been done, and whilst it would be unwise to attempt to draw too precise conclusions from them, some general inferences might be made.

Professor A. J. Sims (Great Britain): The subject of ship motions is one of greatly increased importance at this time, and we are reminded that the study of rolling has progressed further than has the study of other ship oscillatory motions; however, we must be able to predict more accurately the characteristics of pitching, heaving and loss of speed in an ahead sea.

I think we should standardise our nomenclature for periods of pitching. There are three distinct periods, the first being the basic period. It might be defined as in the paper, but we should ignore the coefficient of inertia and also the damping coefficient, leaving the plain straightforward period which can be calculated, knowing the longitudinal weight distribution and the hydrostatic features of the design. That is, however, a period of very limited use.

The second and third periods are practical periods, the second being the "still water at rest" period, and by "at rest" I mean as regards ahead motion. That is a clearly defined period.

The third period is the "under way" period, which is precisely the same as that which I have just discussed, but changes take place in three components of the formula. One is the radius of gyration, the second is in the coefficient of inertia, and the third is in the damping factor.

Dr. J. Lockwood Taylor (Great Britain): In regard to surging, I recall some sea tests I carried out years ago and I make brief reference to the results.

From this paper one might assume that surging is a subject which is little understood; but it is the simplest motion and the one that is best understood, having in mind these particular sea tests. We used Professor T. B. Abell's instrument, the recording short-period pendulum mounted on the long-period pendulum. The short-period pendulum has a stable platform and can record fore-and-aft accelerations. Using this on a cargo liner, I found that the observed surging accelerations could be correlated with the calculated accelerations based on the orbital motion of the waves.

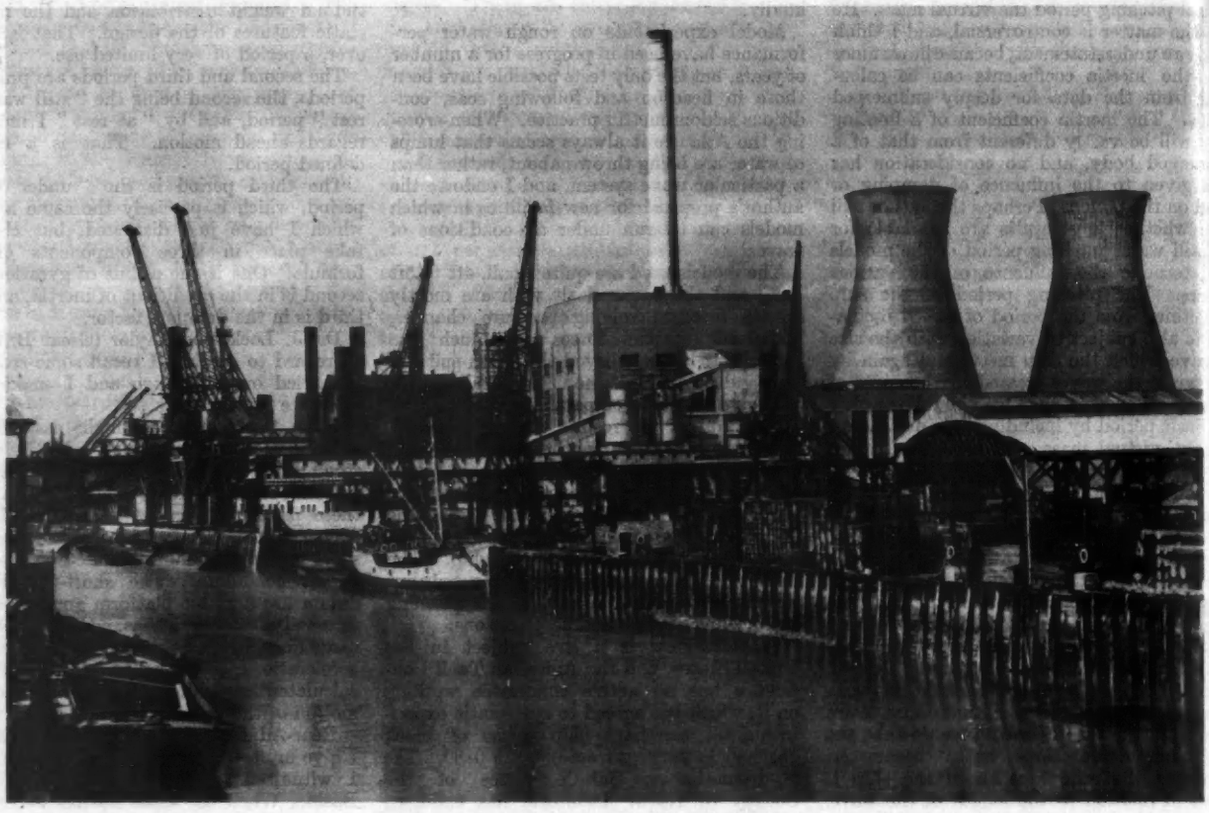
Rear-Admiral C. D. Wheelock (U.S.A.): I give my own reactions to some of the tests I witnessed at the David Taylor Model Basin. When the small models were towed they were given a constant towing force and the wave lengths were varied. The wave heights were considerable, and I think they were too high to be of real value in any analysis. It is probable that the whole range of conditions will have to be exploited until in the model we can simulate approximately what happens to the ship at sea. It appears to me that the wave amplitudes were so great as to force the model out of its own period into the wave period in all the tests, and I suspect it will be necessary to reduce the wave heights to something very small indeed, to try to duplicate the experience at sea, where a ship builds up in pitching to a certain point, then steadies and builds up again, the effect being similar to that observed in rolling.

I wonder whether most of the confusion of the observer at sea is not perhaps due to the smaller waves covering up and hiding the waves that are really affecting the ship. During the crossing made in the "America" there was no time at which anyone could detect the waves which were influencing the ship in pitch, because the periods were too long. Only in the Pacific do we ever find long waves that we can see.

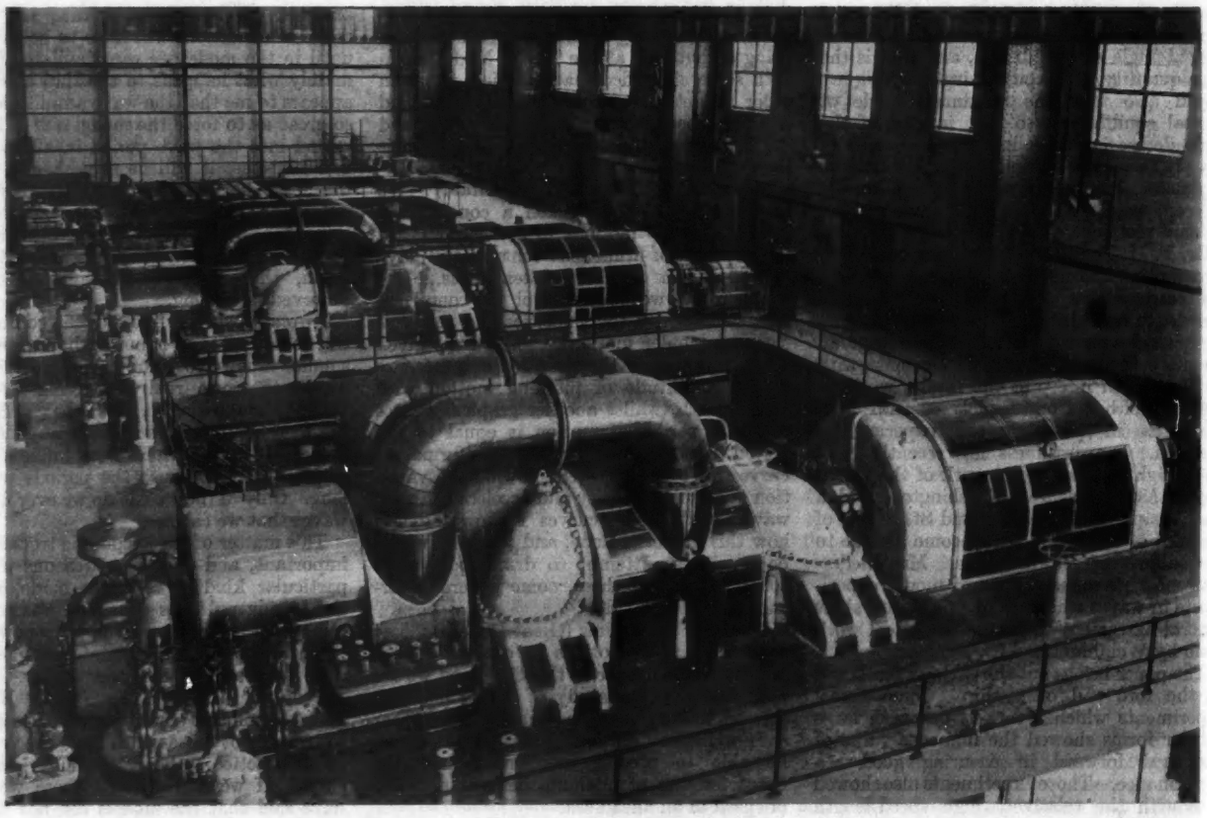
This matter of sea-keeping is tremendously important, and one of the reasons why this particular kind of test was made, wherein the towing pull was constant, was to determine whether, with a given horsepower or a given thrust, we could maintain higher speed in rougher and rougher waves.

Professor E. V. Telfer (Great Britain): It is significant that the two best forms tested are not those which have been reported on in practice as being the most sea-kindly ships. If we had stopped there we should have said that the models did not interpret the ship performance. However, the curves grade the models in respect of low speed loss. On the other hand, it is usual for a captain to

WEST HAM "B" POWER STATION



POWER STATION AND COALING WHARF FROM CANNING TOWN BRIDGE



TURBINE ROOM

say that his ship is sea-kindly, by reference to the amount of water it takes on board. The tests on the two best model forms show that the ships they represent could quite easily keep up to the weather so far as holding speed it concerned, but they would probably be wrongly diagnosed by a captain because some water was being taken on board.

With regard to absolute speed loss, the author states that, whether we start from 20 or 30 knots, roughly the same amount of speed is lost. That is a truth, but I think it is an entirely wrong lesson to learn from the tests. To lose the same actual amount of speed means that there is a greater relative loss when starting from the lower speed. Study of the motions as such will lead nowhere, but study of the effects on absolute power or thrust in facing given rollers is the most important line of attack.

I think the pull necessary to move a particular form at a speed of 30 knots is a very insecure basis. A vessel which needs a certain power for a speed of 25 knots in smooth water and requires a terrific increase of power at 30 knots will show a much better relative performance in holding speeds at lower power. You have to provide so much extra power to achieve 30 knots that you could use it much more economically at 20 knots.

(To be continued)

West Ham "B" Power Station

THE first section of the new West Ham "B" power station, consisting of two 30MW turbo-alternator sets and the associated boiler plant, was officially opened by the Mayor of West Ham, Councillor W. W. Paton, on Wednesday, July 18th. Development of this power station to reach its ultimate designed capacity of 180MW will take place in three equal stages, the first of which is completed, while the second is under construction.

To accommodate the new power station, coal store and cooling towers the 9-acre site, upon which the existing station stands, has been extended to 21 acres, bounded on the south side by Bow Creek, which is a tidal portion of the River Lea, some 600 yards north of the Barking Road. The frontage on Bow Creek has been increased from the original 300ft to 650ft. This site satisfies the primary technical requirement that a power station should, if possible, be centrally placed in relation to its load. Two other important site conditions are to some extent fulfilled by Bow Creek. First, it is the source of make-up water for condenser cooling; unfortunately, the available water is inadequate for direct cooling, which means that cooling towers are necessary. Secondly, the tidal creek allows coal to be transported to the power station by water, subject to the disadvantage that seaborne coal must be trans-shipped into barges for the final stage of the journey.

These advantages explain the choice of the site both for the original station and for the new station, and it is appropriate that a description of the new plant should be prefaced by a brief reference to the early history of its predecessor. Electricity was first generated in West Ham power station, in 1904, by sets driven by reciprocating engines. Various extensions and alterations were made in 1912, and between 1921 and 1930, when the installed plant consisted of four main turbo-alternators, a house set and eleven boilers, with a capacity of 66·5MW. Much of this plant is time-expired and the purpose of the new station is, first, to augment the existing capacity and eventually to replace the old plant.

The first section of the West Ham "B" station has made a valuable addition of 60MW to the generating capacity of the London Division. It has nearly doubled the output of the old and new stations, in which the plant now commissioned totals 117MW, or 4·5 per cent of the total capacity of the division. The second stage of the new station is due to be completed in the winter or spring of 1953. It is expected that, by then, the total generating capacity of the London Division will have reached about 3400MW. West Ham's share will then have increased to 177MW or 5·2 per cent of the divisional total. These figures emphasise the increasing contribution of the station to the load in the near vicinity and to the London Division as a whole.

The history of West Ham "B" goes back to 1939, when the Central Electricity Board gave a direction to the West Ham Corporation for the extension of the existing station by installing, in the existing buildings, a 30MW turbo-alternator and two 180,000 lb per hour boilers and by building a new cooling tower. On the outbreak of war, however, the direction was withdrawn and the changed circumstances at the end of the war suggested reconsideration of the whole project by the consulting engineers, Messrs. Merz and McLellan, in collaboration with Mr. J. W. J. Townley, the borough electrical engineer and manager, and Mr. G. D. Bendix, power station superintendent. New possibilities could be envisaged as a result of the necessity for complete replanning of the area near the power station to make good the devastation caused by air-raids. The new development scheme for this area allowed the corporation to extend the existing 9-acre site to some 21 acres. Post-war plans also provided for a railway connection, which would offer alternative transport for incoming coal supplies. To achieve the maximum development it was decided to build a new station, West Ham "B," alongside the existing station, the installation being so planned that the first four 30MW sets and the associated boilers could be commissioned without seriously affecting the old station. At the same time, provision was to be made for a new coal store, new 11kV feeder switch houses, and for extending the Central Electricity Board's 66kV substation.

The preliminary works contract was placed in the summer of 1946. Work on the foundations of the first stage was started later the same year and was completed within eight months. The first generating set was commissioned in December, 1949, and, the first stage having been completed, progress is now being made with the installing of plant in the second section of the station.

Foundations and Buildings

The power station is built on a thick concrete raft, which rests on a layer of ballast some 10ft thick and about 15ft below ground level. Since the standing water level is only a few feet below the ground, the task of carrying the foundations down to the level of the ballast involved the enclosure of the whole area within a sheet steel pile cofferdam. The piles were driven through the ballast into the clay beneath, thus excluding most of the ground water. Any water that percolated into the cofferdam was dealt with by continuous pumping until the foundations were completed. Most of the pile driving was done with conventional equipment but, because of the scarcity of steel, it was necessary to extract the piles for re-use. This requirement gave rise to some interesting problems, particularly when dealing with the cofferdams in the River Lea, where sheet steel piles had been driven into the heads of old timber piles in the river bed. To withdraw these piles an upward lift of nearly 200 tons had to be exerted and the necessary force was provided by two 100-ton jacks. After lifting the piles about 2ft the normal extracting hammers were used.

In other parts of the site precast reinforced concrete piles driven to a depth of 40ft were used for supporting the foundations. For example, the transformer building was based on concrete piles because the live power cables from the existing station made it impossible to drive continuous sheet steel piling for a cofferdam in this area.

One of the main difficulties has been the large number of buried obstructions. In the area now occupied by the coaling wharf there was, many years ago, a sewerage works on the banks of the river; the associated culverts, in places 20ft below ground level, had to be located by excavation and removed to clear the way for driving the piles.

Originally the station buildings were to have been clad in reinforced concrete but, before work had been started on the main buildings, the steel allocation was reduced. Accordingly it was decided to adopt brickwork instead and a dull red facing brick was used for the superstructure of the main buildings. Because of the limited floor space available for the plant, the chimneys and draught plant were arranged to be built over the boilers at suitable floor levels, the four boilers being served by one chimney supported centrally over the coal bunker bay by a group of four columns. Similarly space limitations in the boiler-house prohibited the use of cross bracing in the building structure. The portal system of construction was therefore used.

The boiler-house roof is 120ft, and the chimney top 318ft, above site level. Concrete construction with curved centring of corrugated sheeting is used for the roof of the boiler-house and the forced draught fan floor. Each of the coal bunkers is arranged to serve two boilers and each bunker has a self-trimming capacity of 1100 tons. A mild steel plate dust screen, which is provided with suitable sliding doors for access, seals the boiler plant against coal dust from the conveyor house and the open top of the bunkers.

The turbine house is 80ft high and has a transverse portal roof with large elevated lanterns designed to prevent stagnation of air at the upper levels. There is a continuous gantry along the full length of the turbine house to carry the 80-ton crane over the generating sets and there is a 12-ton underslung crane serving the auxiliary bay over the feed pumps and feed heaters. The hotwell or surge tanks are installed in independent housings at turbine house roof level over the auxiliary bay.

A 25ft annexe adjoining the turbine house accommodates the transformers and is connected to the main office block and control room buildings, which also include two large switchgear rooms. A separate reinforced concrete building, 80ft square, houses the main feeder switchgear and an adjoining open structure is provided for the main transformers.

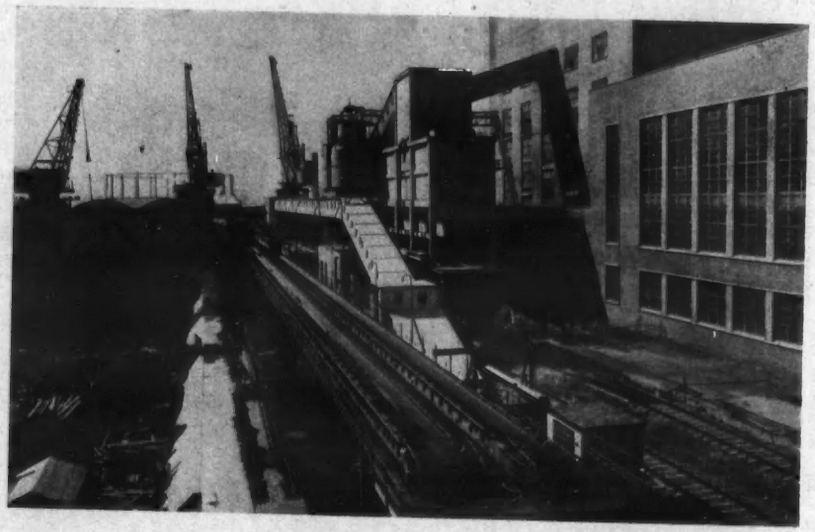
The main office block and control room building is of reinforced concrete: it measures 180ft by 80ft and is, in some parts, 40ft high. The shuttering used in its construction was made from 8ft by 4ft by ¾in plywood sheets with heavy timber frames, which had to be carefully aligned to prevent any variation in the finished surface. After stripping, the external concrete faces were rubbed down by hand with carborundum stone.

Coal Handling Plant

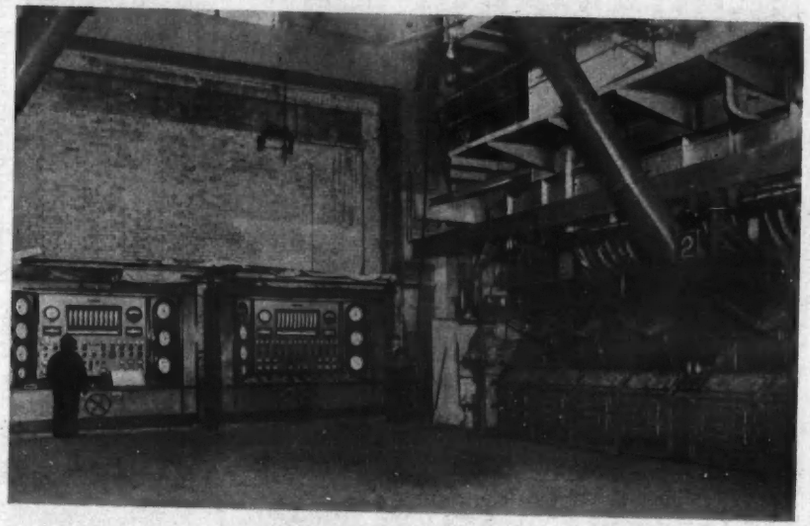
Coal is received either from barges, which are discharged on the wharf alongside the station, or from railway wagons in sidings between the coal store and the station. Provision is also being made to supply the station, at a later date, with coke breeze from a near-by gasworks. River-borne coal is discharged by two luffing jib cranes on to the wharfside coal conveyors, whence it is fed into either of two sections of a mixing bunker at one end of the wharf. A coke conveyor from the gas works will also feed the same bunker. Rail-borne coal is discharged by a combined wagon tippler and weigher into a hopper alongside the rail track, and is then distributed by a line of conveyors to either section of the mixing bunker.

From one section of the mixing bunker the coal is fed to a line of storing conveyors flank-

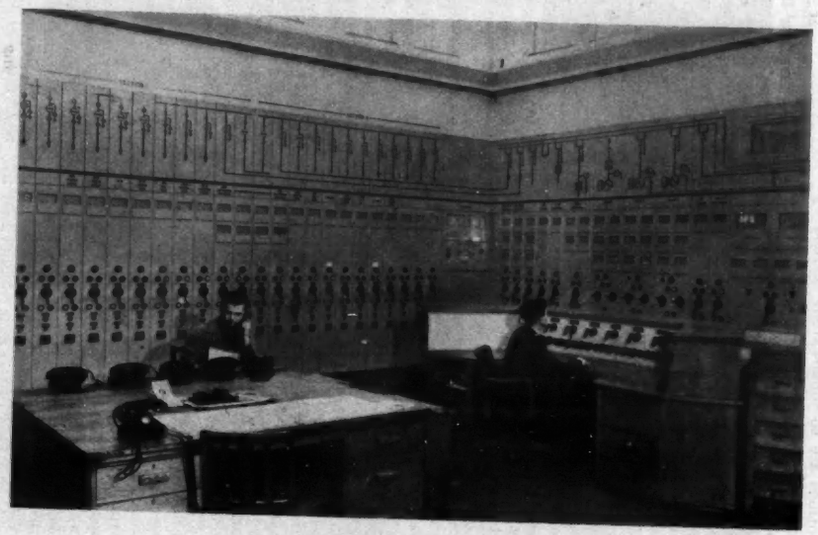
WEST HAM "B" POWER STATION, B.E.A. LONDON DIVISION



COAL HANDLING PLANT



BOILER HOUSE FIRING FLOOR



MAIN CONTROL ROOM

11KV MAIN SWITCHGEAR

ing the coal store (as shown in an illustration on page 84) and is then discharged to a belt conveyor spanning the lower chord of a travelling bridge, for distribution over the running coal store. From the other section of the mixing bunker coal is discharged by jigger feeders to two lines of conveyors feeding the boiler-house bunkers, into which the coal is distributed by automatic travelling tippers. When stocked to a depth of 15ft the No. 1 coal store has a capacity of 21,000 tons.

Reclaiming from the coal store is done by two travelling jib cranes on the travelling bridge. These cranes discharge to hoppers feeding the reclaiming conveyor on the upper chord of the bridge. This conveyor, in turn, feeds a line of reclaiming conveyors alongside the storing conveyor, which flanks the coal store. Finally, the reclaiming conveyors deliver coal to the section of the mixing bunker that feeds the boiler-house bunkers.

Boiler Plant and Turbines

Ultimately the boiler-house will contain twelve John Thompson "Radiant" boilers, designed to burn Northumberland and Midland small coal and additional mixtures of coal and coke breeze containing up to 20 per cent of coke breeze. Each boiler will have an economical rating of 144,000 lb per hour and a maximum capacity of 180,000 lb per hour, the stop valve steam conditions being 640 lb per square inch gauge and 875 deg. Fah. The guaranteed boiler efficiency, based on the higher calorific value of the fuel, is 85·5 per cent when burning coal and 85 per cent when burning a 15 : 85 mixture of coke breeze and coal. Each boiler incorporates a convection superheater and an interstage contact type desuperheater, with automatic control to give a final steam temperature of 875 deg. Fah. The economiser is a Green gilled tube unit and a John Thompson tubular air heater is installed. An interesting detail of the air heater is that cast iron is used for the tubes in the low temperature section, to minimise corrosion, while the remaining tubes are of mild steel. To reduce condensation when starting up or steaming at low rates, the air heater can be by-passed, partially or completely, on the air side. The main heating surfaces are: boiler, 13,345 square feet; furnace (effective), 5866 square feet; superheater, 6215 square feet; economiser, 24,609 square feet; air heater, 21,800 square feet. Associated with each boiler there are two i.d., two f.d., and two secondary Howden air fans.

Firing is by International Combustion, twin "L" type underfeed chain grate stokers. Each boiler is supplied with coal from overhead bunkers by two traversing chutes, which are fed through two automatic Richard Simon coal weighers. Flue gas dust is removed by Howden multi-cell centrifugal separators, which precede the i.d. fans.

Automatic boiler control is provided by the Hagan pneumatic system, arranged so that the individual boilers in each set of four can be supervised from a single master regulator. Besides the individual instrument panels for each boiler, there is a special panel, installed in the combustion engineer's office, where certain selected indicators are centralised.

High-pressure sluicing ash-handling plant is installed. Ash is removed from the hoppers of the first four boilers by high velocity water jets and is discharged along sluiceways, through grinders, into two sumps in the boiler-house basement. At present the installation consists of four boilers in two rows with an ash sump at the end of each row, but each section is designed to be capable of handling the ash from four more boiler units. From the sumps the ash is pumped into a reinforced concrete bunker with a capacity of 750 tons, built over a rail siding along the gable end of the main buildings. In the bottom of the bunker there are three hand-operated water collecting gates, through which the ash is discharged in railway wagons or lorries for disposal. Separate handling plants are provided for ash and dust because the dust-free ash is a saleable commodity.

When the installation is complete the turbine room will house six 30MW, 3000 r.p.m. English Electric turbo-alternators. As shown in the lower illustration on page 82, the sets are arranged transversely across the turbine house, with large well openings between each set. Each turbine is a two-cylinder machine, taking steam at 600 lb per square inch and 850 deg. Fah. The high-pressure cylinder has twenty stages of impulse blading and the double-flow low-pressure section has ten stages of reaction blading in each flow. The condensers are of the usual twin shell construction to allow of cleaning while the plant is in service. There are three passes on the water side of the condensers, the normal water requirements being 21,000 gallons per minute, per condenser, at maximum continuous rating. With a steam quantity corresponding to the economical rating of 24MW and with 18,000 gallons of circulating water per minute at 70 deg. Fah., the guaranteed performance of the condensers is given as a vacuum of 28·5in Hg. Each turbo-alternator set is provided with two main ejectors, one of which is a standby, one quick-start ejector, and two condensate extraction pumps, one being a standby.

A closed circuit feed-water system is adopted for the new station. It is designed to operate with a small amount of overflow from the hotwells to the reserve feed water system, which creates an upward flow in the hotwell balance pipes and thereby ensures an adequate supply of de-aerated water in the hotwells to supply any excess boiler demand. Make-up feed water is taken from the evaporators.

Feed heating is effected up to 340 deg. Fah. in three high-pressure heaters and one low-pressure heater, the drains from the heaters being cascaded back to the condenser through a drain cooler. Steam for feed heating is taken from each turbine at three stages. In addition steam is extracted from the first two turbines to supply the four unit evaporators, each of which has a capacity of 5500 lb at economical rating. Triple effect thermo-compressor evaporators, fed with live steam, are installed in the first extension of the station. Town water, treated by the cold lime-soda process in a Kennicott softener, provides the evaporator feed.

Cooling water for the first section of the station is circulated by three W. H. Allen vertical spindle motor-driven pumps, each of 23,700 gallons per minute capacity. The pump house is situated close to the cooling towers and chlorination plant is provided. Make-up water for the cooling system is pumped from the River Lea by three 2700 gallon per minute pumps. Eventually the cooling water conduit system will comprise 1000 yards of 6ft square inlet and outlet culverts.

Each of the three reinforced concrete cooling towers for the new station is 280ft high, has a maximum diameter of 192ft and stands in a rectangular pond with 9ft depth of water, the designed cooling capacity being 2,800,000 gallons of water per hour. Water is delivered to the towers through 42in diameter cast iron culverts at a temperature of 82·5 deg. Fah. It is cooled to 70 deg. Fah. at a dry bulb temperature of 57 deg. Fah. and 70 per cent humidity. The spray distribution system is mounted on an internal composite stack made up of concrete columns and beams, which support the timber-lath structure. Provision is being made for the installation of spray eliminators to minimise carry-over from the towers.

Electrical Plant

The alternators, which generate at 11kV, are designed to run at loads up to 30MW with a wattless output at any load varying between 22,500kVAr lagging and 11,250kVAr leading, with a cooling air temperature of 40 deg. Cent. Cooling air is circulated by two fans, each capable of meeting the requirements for running at m.e.r. The fans are connected between the air cooler outlet and the alternator inlet and circulating water from the main condenser is used for cooling the air. A main exciter and a pilot exciter with automatic voltage regulator are direct-coupled to each alternator.

Switching of two of the alternators will be done at 66kV and of the other four machines, making the complete station, at 11kV, to feed the loads in the immediate vicinity of the station. For load transfer between the 11kV and 66kV circuits according to operating requirements, there will be two 11kV/66kV transformers. The metal-clad, oil-filled 11kV main switchgear shown in one of the illustrations on page 84 has a rupturing capacity of 750MVA. Supply to the 11kV network is taken through reactors to local switchboards of 350MVA rupturing capacity.

Unit transformers are solidly teed off the connection between the alternators and the switchgear. These transformers give supplies at 3kV and, through auxiliary transformers, at 415V for the auxiliary machinery associated with each turbo-alternator and its boilers.

Starting up and alternative supplies for the 3kV unit boards are obtained from 3kV station boards, which are connected to the 11kV busbars through station transformers. The non-essential auxiliaries are, in general, supplied in groups direct from the station switchboards through auxiliary step-down transformers.

The 3kV and 415V switchgear is indoor air insulated, air-break equipment. The 3kV switchgear has a rupturing capacity of 150MVA and the 145V switchgear and fuse gear a rupturing capacity of 15MVA. The key auxiliary supply circuits are electrically controlled from the central control room, which is illustrated on page 84. Remote control of the 66kV switchgear, 11kV main and distribution switchgear and the key auxiliary supply circuits is carried out from the panels in the operating room. Control of the generators is centralised on a desk in the control room.

All essential auxiliaries—that is, those associated directly with boilers and turbo-alternators and without which the plant could not function—are remotely controlled from the boiler control panel, from positions near the turbo-alternators or in the pump-house. Non-essential auxiliaries, that is, performing general station duties, whose continuous availability is not of over-riding importance, are controlled from the motor concerned.

Special attention has been given to the design, accommodation and protection of electrical equipment to minimise the risk of fire following breakdown of plant. All oil-filled transformers, reactors and similar equipment are installed at ground level and outside the area of the turbine house and boiler-house. Each item of plant is segregated and oil sumps or oil retaining kerbs are provided as required. Mather and Platt carbon dioxide or emulsion-forming water jet equipment is installed for automatic fire extinguishing.

Doors to the various chambers where a fire risk is present are fire-resisting and self-closing. Fireproof seals are provided where cables pass through walls or floors.

The consulting engineers for West Ham "B" power station are Messrs. Merz and McLellan and Sir Alexander Gibb and Partners.

Principal Contractors

The following list gives the principal contractors and sub-contractors :—

Steam-raising plant, John Thompson Water-Tube Boilers, Ltd.; ash extraction plant, B.V.C. Industrial Construction, Ltd.; boiler control (Hagan), James Gordon and Co., Ltd.; coal weighers, Richard Simon and Sons, Ltd.; draught plant, James Howden and Co., Ltd.; economiser, E. Green and Son, Ltd.; feed water control, Copes Regulators, Ltd.; H.p. valves and mountings, Hopkinsons, Ltd.; mechanical stokers, Underfeed Stoker Company, Ltd.; soot-blowing equipment, Hopkinsons, Ltd.; valves, Hopkinsons, Ltd., and J. Blakeborough and Sons, Ltd.

Turbo-alternators, condensers, feed heaters, English Electric Company, Ltd.; cranes, Joseph Booth and Bros.; evaporators, G. and J. Weir, Ltd.; pumps, Drysdale and Co., Ltd.

High-pressure and low-pressure pipework, Aiton and Co., Ltd.; pumps, W. H. Allen, Sons and Co., Ltd., and Worthington Simpson, Ltd.; valves, Hopkinsons, Ltd.; water treatment plant, John Thompson, Kennicott, Ltd.; coal-handling plant, W. J Jenkins and Co., Ltd.; belts, British Tyre and Rubber Company, Ltd.; wagon tipplers, Mitchell Engineering, Ltd.; weighing equipment, W. and T. Avery, Ltd.; jetty cranes, Stothert and Pitt, Ltd.; transporter bridge, Fraser and Chalmers Engineering Works (G.E.C.), Ltd.

Cooling towers, J. L. Kier and Co., Ltd.; composite stack, Film Cooling Towers (1925), Ltd.; foundations and buildings works, Taylor Woodrow Construction, Ltd.; steelwork, Dorman, Long and Co., Ltd.; cables, Standard Telephones and Cables, Ltd.; transformers, British Thomson-Houston Company, Ltd.; lifts, Pickerings, Ltd.; locomotives, Ruston and Hornsby, Ltd.; switchgear, A. Reyrolle and Co., Ltd.; auxiliary switchgear, English Electric, Ltd.; lighting and heating, W. J. Furse and Co., Ltd.; batteries, Hart Accumulator Company, Ltd.; chlorination, Paterson Engineering Company, Ltd.; sidings, Taylor Woodrow Construction, Ltd.

The British Instrument Industries Exhibition

No. III—(*Continued from page 53, July 13th*)

TO conclude our brief descriptive review of the British Instrument Industries Exhibition, held at Olympia from July 4th to 14th, we refer herewith to a final selection from the many exhibits which gave the visitor an impression of the growing scope for instrumentation in industry.

Sunvic Controls, Ltd.

The urgency of restricting the demand for electricity by domestic and commercial consumers at peak load periods gives topical interest to an automatic maximum demand regulator exhibited by Sunvic Controls, Ltd., 10, Essex Street, London, W.C.2.

The regulator is a thermally operated device embodying a bimetal element and a microswitch arranged as shown in Fig. 17. The main load current is fed into the fork-shaped bimetal element *A* through heavy copper connectors *B* and terminal clamps *C* and *D*. Deflection of the element *A* is proportional only to the temperature rise caused by the operating current passing through it; the joint between the element *A* and the machined faces on the copper

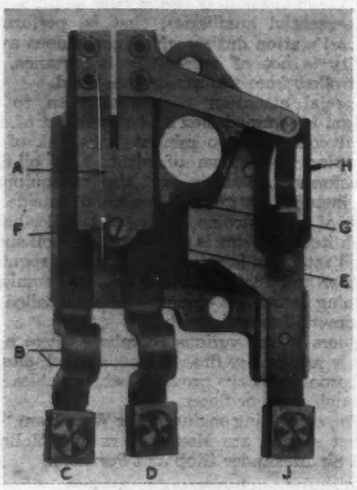


Fig. 17—Maximum Demand Regulator Mechanism—Sunvic Controls

strap is made by substantial rivets to ensure that the heat generated at the joint is negligible.

The passage of current through the element *A* causes it to bend upwards as its temperature rises. This movement is transmitted through an adjustable screw *F* to the compensating bimetal strip *E* (which is pivoted at *G*) and thence to the blade *H* of the microswitch. As the temperature of the element *A* rises it moves away from the compensating strip *E* and the force exerted on the switch blade is progressively reduced until the switch opens. With this arrangement, therefore, heavy overload cannot result in mechanical damage.

In a typical application the control circuit is shown diagrammatically in Fig. 18. With the water heater in circuit alone the switch *H* will remain closed. Connecting a load at *D* will have the effect of increasing the deflection of the element *A* until, if the additional load exceeds 3kW, it will be sufficient to open the switch *H* and disconnect the water heater, reducing the total load by 3kW. The element will then cool and the switch will reclose and the cycle of operations will be repeated. Increasing the value of the load *D* will cause a progressive reduction in the average energy input to the water heater. If the load *D* reaches 6kW the water heater will remain disconnected. This method of regulating the water heater circuit effectively limits the total load on the consumer's circuit to 6kW and it does so with the minimum of inconvenience to him and with the minimum loss of revenue to the supply authority.

The regulator is housed in a black Bakelite case arranged for wall mounting and measuring

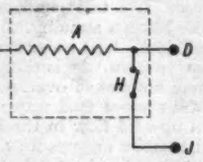


Fig. 18—Maximum Demand Regulator Circuit—Sunvic Controls

approximately 7¾in by 5 13/16in by 2in overall. The case provides two compartments: the upper part contains the mechanism and has a separate lid, which is sealed by the manufacturer. The lower part is the terminal chamber and has a separate lid with provision for sealing after installation.

The Baldwin Instrument Company, Ltd.

The rolling of steel strip to produce a controlled amount of work hardness to make it suitable for deep drawing demands precise measurement of the change in thickness which occurs as the strip leaves the rolls. This change varies from about 0·5 per cent to 3 per cent and the reduction must be measured on strip which may be travelling at a speed of, perhaps, 1000ft per minute. As most of the extension takes place in the direction of rolling, the task of measuring the linear extension corresponding to the change in thickness resolves itself into that of measuring the ratio of the velocity of the strip entering the rolls to its velocity on leaving

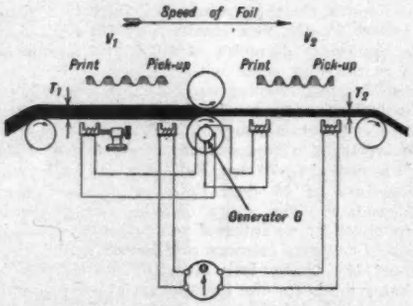


Fig. 19—Simplified Diagram of Rolling Mill Extension Gauge—Baldwin

the rolls. A method of making this measurement by imprinting a magnetic pattern on the strip before rolling and determining the change in the pattern produced by rolling forms the basis of an instrument (Figs. 19 and 20) exhibited by the Baldwin Instrument Company, Ltd., Dartford, Kent.

The principle of this extension gauge is shown diagrammatically in Fig. 19. An a.c. generator *G* is driven from the rolls and its output is fed to two electromagnetic "printing" coils which are displaced relatively to each other across the width of the strip. That on the ingoing side is adjustable by a micrometer and the other one is fixed. The coils produce a magnetic "pattern" in the steel, the form of which is independent of the roll speed. Two "pick-up" coils, one in line with each printing coil, pick up the patterns, which, after amplifying, are fed to a phase-selective indicating detector *O*.

If no reduction were taking place the speed of the strip would be the same on both sides of the rolls and the outputs of the two "pick-up" coils would be in phase and therefore cause no deflection of the indicator when the distance between each pair of coils was identical. If, now, a 1 per cent reduction in thickness is required phase coincidence will occur, with this reduction, when the ingoing speed is 1 per cent less than the outgoing speed and the distance between the ingoing pair of coils is 1 per cent less than that between the outgoing pair.

The method of using the gauge is therefore to set the micrometer carrying the ingoing "printing" coil to the required distance, the micrometer being calibrated in per cent reduction, and then to adjust the mill so that the phase detector indicates zero. The indicating instrument is separately mounted on the mill control panel under the eye of the operator. The electronic part of the magnetic extension

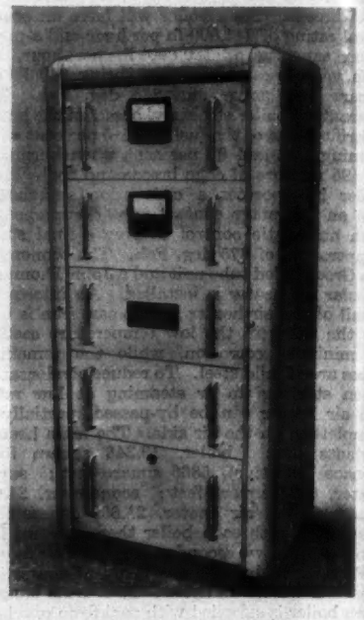


Fig. 20—Steel Strip Extension Gauge—Baldwin

gauge is illustrated in Fig. 20. With this instrument it is possible to detect variations in reduction of considerably less than 0·1 per cent even on thin strip.

Another instrument which was shown by the same company is known as the "Statigun" static charge detector, which was developed to the design of the Dunlop Rubber Company, Ltd., for detecting and measuring stray charges induced by friction on rubber belting and other insulating materials. The instrument consists of a small portable electrometer arranged in the form of a pistol; a small electrode in the head or barrel of the instrument collects any local charge which is indicated in microcoulombs per unit area.

W. Edwards and Co. (London), Ltd.

Control of the quality of light alloy castings by detecting the gas content of a melt is simplified by the use of the test apparatus which was exhibited by W. Edwards and Co. (London), Ltd., Worsley Bridge Road, Lower Sydenham, London, S.E.26. The equipment (Fig. 21), which is a commercialised version of apparatus devised by the British Non-Ferrous Metals Association, is designed so that tests can be carried out in a few minutes by comparatively unskilled operators. Each melt can be tested on the foundry floor before casting to determine whether an excessive amount of gas has been

picked up in melting or whether degassing treatment has been satisfactory.

The test depends on the fact that light alloys form tenacious oxide films, which are only slightly permeable to gas dissolved in the metal. Moreover, the currently used aluminium-based casting alloys form a "pasty" mixture of solid and liquid metal during freezing from the molten state. Under these conditions if a sample of molten metal is subject to reduced pressure (ordinarily 20mm of mercury), the gas dissolved in it cannot escape by diffusion through the metal surface during cooling. The trapped gas forms bubbles in the "pasty" interior, which inflate to a greater volume than they would occupy if the metal was under atmospheric pressures, and which tend to break explosively through the surface of the sample as it cools and solidifies.

Hence either or both the following phenomena will be seen if any aluminium-based alloy containing dissolved gases is allowed to freeze under vacuum in the Edwards test apparatus :—(*a*) Bubbles breaking through the surface of the solidifying sample ; or (*b*) swelling of the whole sample. Ordinarily the test is qualitative although it can be made roughly quantitative if the test conditions are strictly controlled, the more important of these conditions being the metal temperature, the test pressure and the temperature of the vacuum chamber.

The apparatus shown in Fig. 21 comprises a ribbed, vacuum-tight test chamber and a system for producing, controlling and measuring the vacuum.

A "Speedivac 1S50" pump mounted on the lower platform of the trolley serves to evacuate the test chamber, the rate of evacuation being controlled by a valve which can also be used to isolate the chamber from the pump. The chamber pressure is measured by a "CG-1" barometrically compensated, aneroid dial gauge

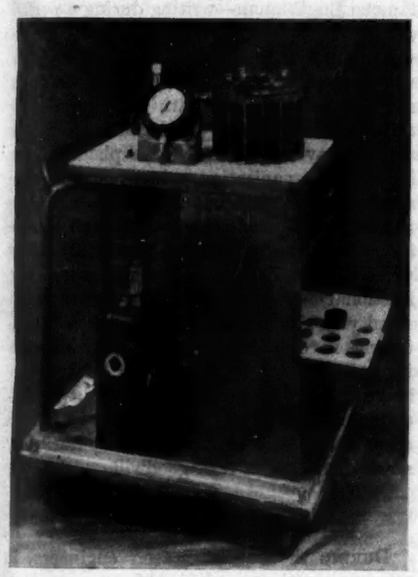


FIG. 21—LIGHT ALLOY MELT GAS TESTER—EDWARDS

and the air inlet enables the vacuum to be broken. A hinged lid, which is vacuum-sealed by a synthetic rubber "O" ring, covers the vacuum chamber, inside which the test sample may be observed through a hard glass window.

The molten metal sample is contained in an uncoated iron crucible which is supported in the vacuum chamber by a fireclay triangle. The entire apparatus is mounted on a trolley with 5in diameter castors for mobility on a foundry floor. The table top is 30in high and the body measures 25½in by 16½in. Shelves are fitted for the storage of crucibles, specimens and tools.

In operation the crucible is preheated by "washing" in the test melt and a sample of the liquid is taken. The crucible and sample are placed in the vacuum chamber and the lid is closed. After closing the air inlet valve and opening the control valve alongside the dial gauge the pump is started. Evacuation can take as little as ten seconds, a test pressure of 20mm of mercury being suitable for most purposes.

The surface of the sample is observed during freezing for the appearance of gas bubbles. If it is substantially gas free no bubbles will appear and the surface after solidification will be depressed. The appearance of a few bubbles towards the end of freezing, coupled with a slight rising of the surface, indicates the presence of a small amount of gas, but not necessarily sufficient to render unserviceable the castings made from the melt. If, however, many bubbles are observed and the surface

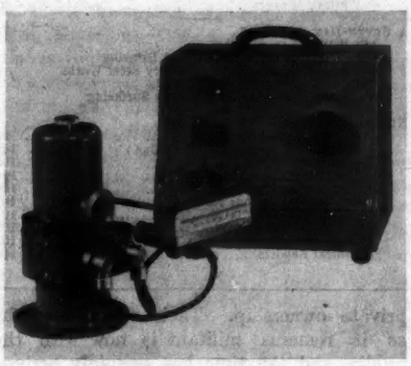


FIG. 22—KNUDSEN GAUGE—EDWARDS

of the sample rises during freezing the metal is very gassy and the melt requires treatment before sound castings can be poured. After the sample has completely frozen the vacuum is broken by opening the air inlet valve and the crucible is removed.

The behaviour of the sample during solidification provides a sufficient estimate of the gas in the melt for the purposes of normal casting. For a closer estimate the specimen may be sectioned when cold, or its density measured and percentage porosity calculated.

Another instrument exhibited for the first time is illustrated in Fig. 22, which shows the Knudsen gauge developed in the form of a robust laboratory instrument for measuring very low pressures.

In this instrument a light metal vane is suspended so that it can rotate about its vertical axis, in an evacuated housing with a low-temperature heater arranged on each side of the vane. At pressures low enough to eliminate convection effects the gas molecules from the heaters strike the vane with greater momentum than the molecules from the cold walls and exert a torque proportional to the number of bombarding molecules—that is, to the pressure. The deflection of the vane is measured optically.

Knudsen showed that, if T_1 was the heater temperature, T_0 the temperature of the cold walls of the casing, and p the pressure of the gas to be measured, then the force F per unit area on the vane was given by

$$F = \tfrac{1}{2}kp(T_1/T_0 - 1),$$

k being a constant depending on the dimensions of the gauge. This formula is independent of the molecular weight of the gas and it follows that the calibration of the gauge is independent of the gas composition.

In the form of Knudsen gauge considered here the vane consists of a thin metal foil, ribbed to provide rigidity, and suspended at the top and bottom by strip torsion filaments which are fixed to spiral plate springs of beryllium-copper to provide the correct tension and resilience of mounting. The upper suspension filament carries a mirror with an aluminised reflecting surface and there is a suspension clamp to protect the movement during transport. An external vacuum-tight adjustment allows the upper suspension support to be turned as required for zeroing. The heaters consist of ribbon-wound elements fed from a stabilised low-voltage source giving an evenly heated flat surface. Vacuum-tight seals provide entry for the leads into the housing.

Since the suspension would normally be highly periodic under vacuum conditions, magnetic damping is provided by a strong permanent magnet outside the housing, the poles being diametrically opposite the vane.

Light for the optical indicating system is derived from a 6V, 3W lamp and a lens, which are mounted in a tubular housing rigidly attached to the body. Light from this source is projected on the suspension mirror through a window sealed with an "O" ring and is reflected back on a translucent scale carried by the lamp mounting as shown in Fig. 22. Connection to the vacuum system is made at the base of the body of the gauge by means of a large-diameter flange joint sealed by a fully trapped "O" ring.

All the controls for the instrument, except the mechanical zero adjuster, are housed in a sheet metal cabinet (as illustrated). It contains a stabilised transformer for direct a.c. mains operation on 200–250V, 50c/s, the power consumption being 20W. The instrument is normally supplied with 6ft leads for mains and gauge head connections.

The pressure range of the gauge is determined by the voltage at which the heater system operates. A switch on the control unit allows either of two ranges to be selected, corresponding to two preset heater voltages. Typical calibrations are as follows :—(*a*) Voltage, 2·5V ; approximate sensitivity, 10^{-6}mm scale divisions per mm mercury ; range, 10^{-4} to 5×10^{-7}mm mercury ; (*b*) 10V ; approximate sensitivity, 2×10^{-7}mm scale divisions per mm mercury ; range 2×10^{-5} to 10^{-7}mm mercury.

The two predetermined voltages can be checked on the control unit voltmeter, adjustment being made, if necessary, by screwdriver-operated potentiometers.

The International Welding Congress

On Saturday last, July 14th, a Government reception was held at Lancaster House in London for the delegates and representatives of welding societies from seventeen countries to an international welding congress organised by the International Institute of Welding. The technical meetings opened at Oxford on Monday last, and on Wednesday papers on welding in bridges and structures were presented and discussed under the chairmanship of Professor J. F. Baker. The papers dealt with on that day were :—"Control of Cracking in the Metal Arc Welding of High-Tensile Structural Steels," by Mr. C. I. M. Cottrell, Dr. M. P. Jackson and Dr. J. G. Whitman ; "Possibilities of Prestressing of Metal Constructions," by Professor W. Soete ; and "Powder Processes—a New Industrial Tool," by Dr. A. B. Kinzel, Mr. D. Swan, Mr. H. Biers and Mr. H. R. Pufahl. On the following day papers on the welding of the wrought light alloys, presented and discussed under the chairmanship of Sir Arthur Smout, included "British Experience in the Argonarc Welding of Aluminium," by Dr. E. G. West ; "Recent French Studies in the Weldability of the Aluminium Magnesium Alloys," by Mr. J. Herenguel and Mr. M. Hollard, and presented by Mr. H. Granjon ; and "Recent Advances in the Technique of Electric Spot Welding of Aluminium Alloys in the French Aircraft Industry," by M. J. Faguet. On the same day Sir Donald Baily presided over meetings dealing with recent developments in welding in Great Britain. During this session Mr. H. E. Lardge presented a paper on "Welding on Gas Engines for Aircraft," Dr. J. M. Robertson one on "Welding in Relation to Gas Turbines for Use on Land," and one by Mr. W. S. Atkins and Mr. E. M. Lewis on "Developments of Design and Fabrication in Recent British Structures." To-day the reports of commissions of the International Institute will be presented by their chairmen. Next week overseas visitors will tour works and shipyards in various part of the country.

THE ENGINEER

Vol. CXCII JULY 20, 1951 No. 4982

Contents

PAGE

LEADING ARTICLES—
Duty of Trade Unions ... 88
Cross-Channel Services ... 88

SPECIAL ARTICLES—
Davis Dam Project, U.S.A. No. I. (Illus.) ... 75
International Conference of Naval Architects and Marine Engineers. No. III ... 79
Requirements of a Good Tolerance System. (Illus.) 76
Retirement of Sir Gerald Chadwyck-Healey ... 89

Automatic Digital Computer at Manchester University. No. II. (Illus.) ... 91
British Institution of Radio Engineers' Festival Convention ... 90
British Instrument Industries Exhibition. No. III. (Illus.) ... 86
Caisson at Uskmouth Power Station. (Illus.) ... 93
Diesel Industrial Locomotive with Hydraulic Transmission. (Illus.) ... 95
George Montefiore Prize ... 90
International Welding Congress ... 87
National Coal Board's Anthracite Project ... 95
Range of Diesel Engines. (Illus.) ... 98
Repair Control System ... 94
Simon Engineering Group Research and Development Building. (Illus.) ... 97
Track-Laying Cranes ... 94
West Ham "B" Power Station (Illus.) ... 83
16in Axle Lathe. (Illus.) ... 99

LITERATURE—
Books Received ... 90

OBITUARY—
Sir Harry Brand ... 89
Neville G. Gwynne ... 90
Col. Frank Hibbert ... 90

A SEVEN-DAY JOURNAL ... 73
Alkali Works in 1950
Non-Ferrous Ore Treatment and Dressing
Opening of the Margam and Abbey Steel Works
Railway Accident Inquiry Reports
Rubberised Bitumen for Highway Surfacing

NEWS AND NOTES—
American Engineering News ... 99
British Patent Specifications. (Illus.) ... 103
Contracts ... 102
Forthcoming Engagements ... 104
French Engineering News ... 100
Industrial and Labour Notes ... 101
Launches and Trial Trips ... 104
Notes and Memoranda ... 102
Personal and Business ... 102
Technical Reports ... 104

THE DUTY OF TRADE UNIONS

WE note that one of the unions affiliated with the Trades Union Congress has asked for a Government inquiry into the working of the trade unions. "Great power" (remarked the spokesman for this particular union) "is concentrated in a few hands, and we have seen in consequence dissatisfaction arising in the rank and file." There will be many, inside and outside the organisations, who, acquainted with industrial conditions to-day, are likely to be in agreement with this request. The momentous changes made during the last few years (changes in which the trade unions have played a prominent part) have materially altered the climate of industry. Great power—including legislative power—has passed into the hands of trade union leaders, and it is to be expected that this power will be associated with a deepened sense of responsibility. We honour the achievements of trade unionists and in particular do we honour the individual craftsman as the backbone of technical industry. But no longer is there any occasion for fighting against predatory foes who have ceased to exist. A scarecrow is worth-while only when it can be positioned where there is something to scare. Set up anywhere else it becomes a manifest absurdity, and trade union statesmanship—like all other statesmanship—must conform to changing situations. One such change is seen in the passing from private to public ownership, of certain basic industries. To what extent has this fundamental change affected the outlook of those trade unions which have been built up from the personnel of such industries? It does not appear that the great enlargement of the area of public ownership has been allowed to affect either the income or the policy of the unions, a situation which seems akin to maintaining expensive standing armies against an enemy who has not only left the field but ceased to exist. While we may agree that such trade unions still have their *raison d'être*, we cannot but realise that no longer are they confronted with what they previously denounced as the menace of private ownership. Their contest—so far as it remains militant is now with the public, and the time has certainly arrived when the scarecrows, turnip lanterns, conventional catchwords and other superannuated absurdities of the labour agitator should be not only abandoned, but forgotten. What remains as the principal objective of the trade unions? Surely it is to promote the prosperity of the industries in which their members, as citizens, have become part owners.

The need to-day is for trade union leaders who are wise enough to recognise and big enough to declare that the standard of living of the men whom they represent—and of their children—depends, not upon words and politics, but upon thought and efforts. Co-operation in management means a true interlocking of activity and requires that every man will do his best, and, while having regard to his rights, will show at least equal regard to his duties. What a sensation a trade union leader would make if he came out with a declaration that for the future he would regard it as a solemn obligation that the first thing to achieve was the friendly co-operation of all partners in industry; that the infliction of hardship or suffering as a means of gaining the upper hand is not only a callous but a suicidal proceeding and must give place to other methods; that every possible effort should be made to increase efficiency and avoid waste of any kind, particularly waste of time; that no honest man who has come upon hard days should be without succour. On this last point we do well to recall certain words printed, at a period of extreme difficulty, in one of the annual reports of a great engineering industry: "We consider it our primary duty to endeavour to maintain our personnel in employment." If this be the objective of private enterprise, it should surely be the primary duty of trade union leaders and members to support such management by all the means in their power. We read of one trade union, which to-day employs 650 full-time officials, a clerical and professional staff of more than 600 and supports twenty-two Labour Members of Parliament. Such a body obviously includes many able men whose abilities, directed to the encouragement of national prosperity, would be in the highest degree valuable. When danger from the malice of the enemy threatened the nation these men did not hesitate to use their strength to the utmost. Now that we are confronted by danger of another kind, this danger should be met and overcome in the same spirit.

We have passed from the phase when combination on the one side was the necessary counterpart to combination on the other. The phase in which we now find ourselves demands, for common survival, that both sides combine for the sustenance and welfare of all. This combination must, however, be based on activity directed to the elimination of wasted effort, wasted material, lost time, idle capital and idle equipment. The wise trade unionist and the wise employer must realise the vital need to preserve and promote initiative, diligence, responsibility, and interest. They will also realise that these desirable things are apt to be lost where human relationship in industry is extinguished and consultation is no longer a matter of individual contact, but of policy decisions reached at a level which the individual man feels to be utterly remote. The bigger the organisation the larger is the radius from centre to circumference, and in labour questions it is circumferential contact that counts. More than four centuries ago a famous Englishman—writing during a period of great change—remarked that "There was never any thing by the wit of man so well devised, or so sure established, which in continuance of time hath not been corrupted." It is true of all human institutions and we have surely reached a phase in our industrial organisation when changes are not only imminent but inevitable. Among them must be such changes as shall render industrial disputes free from irrational actions which inflict injury not only upon the irrational few, but upon the entire community. The cumulative effect of these injuries is to weaken the nation and degrade its standard of living. There should no longer be two sides in industry, but a concerted effort by all participants, in which effort each section strives for that harmony never denied to men of goodwill.

CROSS-CHANNEL SERVICES

DURING the tourist season engineers, in common with members of many other professions, turn their thoughts away from their normal duties to other attractions, and many feel drawn to a holiday on the Continent. Others have to cross the seas for business reasons. But one and all are interested in the Channel passages and in the vessels employed, while those who are unfortunate enough to be indifferent sailors are anxious to be assured that the crossing will be as brief as possible, and the ships both steady in a seaway, and as large as harbour limitations and other considerations will permit. At this season of the year, then, it is worth discussing the position to-day, and considering whether it is better or worse than in those days when there was competition between various railway and steamship companies. On the shortest sea route from

Dover to Calais the time taken for the crossing turns out to be much the same as it was fifty years ago. But the steamers then were paddle boats with very little shelter deck. Changes were, however, taking place. Immediately before the 1914 war the triple-screw turbine vessel had asserted itself, and only two paddle boats remained, both of which were French owned. On the rival route of the London and South-Western Railway, the average tonnage of the steamers sailing from Southampton was 1140 gross, all twin screw, and by 1914 the geared turbine had been introduced, and the tonnage had increased to an average of 1360 gross.

Nowadays, the steamers employed on the short sea passage are all of the single-reduction geared turbine type, and their average tonnage is 2360, a marked advance. Generally speaking, the trend has been to increase the size of the vessel, but not its speed. Indeed, it is remarkable that, whereas forty years ago the mail steamers sailing between Holyhead and Kingstown (Dun Laoghaire) were advertised as maintaining their 24 knots, to-day the speed is but 21 knots, and a similar decline has taken place on the longer passages to the Isle of Man. At a time when competition from the aeroplane is becoming more pronounced, it would seem at first sight to be a good policy, especially for the longer routes, to increase rather than decrease the speed. But the fact that an increase of a few knots in speed necessitates a very large increase in horsepower and, therefore, of running costs, affects the issue. Actually, more passengers are using the cross-Channel services now than before the war, and undoubtedly more is done for their comfort, in that the accommodation in the newer ships is more like that found on the ocean liner, and the decks are sheltered to such an extent that very little open deck is available. Foreign vessels give less saloon but more deck space, and perhaps a midway course between British and foreign practice would be the best. The idea of a Channel tunnel comes to the fore from time to time, but as long as military and political reason forbid it, it is useless to bring it into consideration. Perhaps the best solution is to be found in the train ferry, especially for night passages. Those in use have proved so popular that another is now nearing completion for the French railways, to take its place with the ferries that are now operating between Dover and Dunkirk. The fact that the bulk of the cross-Channel traffic is confined to a few weeks in the summer, and that the greater part of this seasonal work is concentrated in the week-ends, produces a problem that would appear to be almost insuperable. The passenger sometimes bitterly complains of overcrowding, while the shipowner with considerable justification avers that he cannot afford to maintain tonnage that will remain idle for the greater part of the year. Too much cannot be expected from urging mid-week travel, as hotel and other bookings make this difficult, and the only answer seems to be to work the ships to full capacity giving as many sailings as possible during the peak period. The question then arises as to whether the shipbuilder is doing all in his power to provide the best vessel for the traffic, and for this to be possible co-operation between builder and owner is essential.

Looking back over the past it is apparent that the cross-Channel steamer has been a very fertile field of research, for new ideas can be tested in cross-Channel ships at a relatively low cost, and if successful, applied to the ocean liner. We remember, for instance, the "Bessemer," with her swinging saloon, and "Castalia," with her twin hulls. They were, perhaps, freakish vessels, even though both showed a laudable desire to solve the problem of eliminating undue motion. But some very interesting craft, pioneering more practical ideas, have taken their place on cross-Channel services. After the turbine had been successfully tried on a Clyde excursion steamer, the principle was adopted on "The Queen," on the Dover-Calais route, this being the first application to a vessel that sailed all the year round, and the geared turbine was also tried first on London and South-Western Railway cross-Channel steamers. The high-pressure boiler was first tried on a Clyde steamer, and pulverised fuel firing in Babcock boilers was first tested on a cross-Channel boat. The attempt to minimise rolling by using stabilisers was so successful when initially applied to a cross-Channel steamer that it was not long before the principle was adopted for larger vessels. We wonder if this spirit of enterprise is as evident at present, for it is some time since a ship of the class under consideration has tried out something really novel. Might the "blister" or "bulge" that has found favour for the excursion boat as a means of providing more deck space be tried for cross-Channel work? Could not experiments be made with gas turbine propulsion? No doubt there are other fields still open to exploration. But we cannot help wondering whether, the energising spirit of competition being now less apparent, the same vigorously experimental spirit in cross-Channel ship design will exist in the future. It will be a pity if it dies. For the rapid advance of marine design benefited greatly from it.

Retirement of Sir Gerald Chadwyck-Healey

At the annual general meeting of Morgan Brothers (Publishers), Ltd., proprietors of The Engineer, on July 6th, the retirement of Sir Gerald Chadwyck-Healey, Bt., C.B.E., from the Board of Directors, was announced. Sir Gerald is the grandson of Mr. Edward Charles Healey, the founder of The Engineer. He came to The Engineer, Ltd., in 1895, and was appointed a director in 1904. In 1919 he succeeded his father, the late Sir Charles Chadwyck-Healey, Bt., K.C.B., as chairman of the company and on its amalgamation, in 1929, with Morgan Brothers (Publishers), Ltd., he was appointed chairman of the new company. This position he held until March, 1948, when he vacated the chair, after an occupancy of twenty-nine years, retaining his seat on the board.

During the first World War Sir Gerald held the appointments, at the Admiralty, of Assistant to the Controller of the Navy (1917) and Director of Materials and Priority (1918) and received the C.B.E. for his services. He was also appointed to the order of the Crown of Italy in the rank of Commander. His many associations with the engineering industry have contributed in no small measure to the distinction with which for so many years he has held office and, indeed, to the reputation of this journal, which he has served so faithfully.

Sir Gerald's retirement does not sever that connection of his family with the fortunes of The Engineer, which has now

Sir Gerald Chadwyck-Healey

lasted ninety-five years. His son, Mr. Charles Chadwyck-Healey, O.B.E., is now assistant managing director of Morgan Brothers (Publishers), Ltd. His brother, Mr. Oliver Chadwyck-Healey, is chairman of the company, and his nephew, Mr. John Chadwyck-Healey, has recently joined the staff.

Obituary

SIR HARRY BRAND

Sir Harry Brand, who died peacefully on July 5th, after a long illness at his home, Harecomb, Crowborough, Sussex, was born on October 2, 1873, and was the fourth son of the late James Brand of Glasgow. He was educated at Stonyhurst and at Glasgow University. On leaving the University he trained as an engineer with J. and A. Leslie and Reid, consulting engineers, Edinburgh, and later in London as an assistant engineer under Sir John Wolfe Barry. In 1899 he returned to Glasgow and joined his father in the family firm of Charles Brand and Son, civil engineering contractors, which had been founded by his grandfather in 1828. The firm was engaged at that time in the construction of Grangemouth Docks for the Caledonian Railway Company, for which work Sir John Wolfe Barry was the consulting engineer. After a short time his father handed over the whole responsibility for this difficult contract to him and took him into partnership in 1901. On his father's death, in 1909, he became the senior partner and, when the firm became a private limited company in 1934, its chairman. He thus spent virtually the whole of his active life with the family firm and, under his direction, it carried out many important contracts. Shortly after the 1914–18 war he moved the headquarters of the firm to London and took a very active part in the London Underground extension schemes and improvements of the inter-war years. Amongst other schemes for which the firm, under his guidance, were responsible were the Golders Green extension, the Morden extension, enlarging the tunnels from Euston to the Angel, improvements at Old Street, Kennington, Trafalgar Square and St. Pauls, the Finsbury Park to Cockfosters extension,

the Baker Street to Finchley Road extension, the Highgate extension, the Liverpool Street to Bow Road extension and the Wanstead to Gants Hill extension. In addition to these works the firm also carried out during this period work for the P.L.A. on the East India and Millwall Docks improvements, for the Southern Railway at Southampton and on the Isle of Wight, the circulating water tunnels for Portishead power station, the Royal Edward Docks extension at Avonmouth and the Dartford-Purfleet pilot tunnel. During the war amongst other major works were constructed the Royal Ordnance Factory at Bridgwater, deep shelters at Clapham, the new Gloucester power station and deep water wharves at Belfast. Since the war the firm has built power stations at Kingston and at Bromborough and the pedestrian and cyclist tunnels with escalator approaches under the River Tyne at Jarrow.

Besides his active business life, Sir Harry was a prominent member of the Federation of Civil Engineering Contractors, being one of those originally approached by the late Lord Cowdray when it was being formed in 1919. He was an original member, not only of the Federation, but also of its council, of which he remained a member until his death, being chairman of council in 1927–28 and president from 1936–1940. From the start of his connection with the Federation of Civil Engineering Contractors, he took a great interest in the setting-up and activities of the conciliation machinery, which has proved so successful in that industry. He represented the Federation on the British Employers Confederation, of which he was president from 1940–1944. During this period he was constantly in touch with the various Ministers and Government Departments, in particular the Ministry of Labour, in all matters affecting the full mobilisation of the country's resources. During the war period he also served as regional works adviser for the South Eastern Region under the Minister of Home Security. He received the honour of knighthood in 1942.

He married in 1905, Mercedes, younger daughter of the late F. Harwood Lescher, who survives him, together with two sons and three daughters.

NEVILE G. GWYNNE

ENGINEERS, particularly those of the older generation, will learn with deep regret of the death of Mr. Nevile Gwyn Gwynne, which occurred, following an accident, on July 9th, at his home at Deans, Piddinghoe, Sussex, in his eighty-third year. Mr. Gwynne was, up to the time of his death, managing director of Gwynnes Pumps, Ltd., of Hammersmith and Lincoln, a family firm with which he had been actively associated for over sixty years.

Nevile Gwynne, who was born on August 2, 1868, was the son of the late Mr. J. E. A. Gwynne, of Folkington Manor, Sussex. He was educated at Lancing College and at Pembroke College, Cambridge, where he was one of the first engineering graduates. On leaving the University, Gwynne went to the works which his grandfather had established in Essex Street, Strand, for the manufacture of centrifugal pumps. His father, James Gwynne, was one of the directors at the time, and the works were subsequently moved to Brooke Street, Holborn, where, in 1892, Nevile became manager. Meanwhile, other members of the family had set up a separate business at Hammersmith, under the title of J. and H. Gwynne, Ltd. In 1912 the two companies joined forces as Gwynnes, Ltd., at Hammersmith, and Nevile Gwynne became director-in-charge. During the first World War, Mr. Gwynne took a prominent part in the introduction and manufacture of the Clerget rotary aero engine, his services being recognised by the award of the C.B.E. in 1920.

In 1927 Gwynnes, Ltd., transferred the greater part of its manufacturing activities to Lincoln and became associated with William Foster and Co., Ltd. Gwynnes Pumps, Ltd.—which is now the registered title of the firm—celebrated its centenary in the business of pump making in 1949. During his long years in the firm's service, Nevile Gwynne proved his high qualities of leadership and technical ability.

Mr. Gwynne was an active member of the Council of the British Engineers' Association, of which he was president in 1921–1922, and also served on the grand council of the Federation of British Industries for a number of years. He was a Member of the Institution of Mechanical Engineers and of the Institution of Naval Architects.

COLONEL FRANK HIBBERT

THE death has been announced of Col. Frank Hibbert, C.B., C.B.E., M.C., T.D., D.L., M.Eng., M.I.C.E., F.G.S. Col. Hibbert was Deputy Lieutenant of the County of Lancashire for the past five years and water engineer for Liverpool Corporation since June, 1934. He was a member of the executive committee of the British Waterworks Association and served on the committee which presented the report entitled "Organisation of the Water Supply Industry," which has recently been published; he was also a member of the Central Advisory Water Committee of the Ministry of Local Government and Planning. Colonel Hibbert was a member of the National Joint Industrial Council of the Water Industry and a past-president of the Institution of Water Engineers and of the Liverpool Engineering Society. He was well known as a military engineer and served during the 1914–18 war in the Royal Engineers. Before his appointment at Liverpool, Col. Hibbert was for ten years with the Swansea Corporation, where he attained the position of water engineer and manager. From 1907 to 1911, which included his period of training, Colonel Hibbert was engaged in the construction of a large gravitation waterworks at Kinder, for the Stockport Corporation. For the following two years he was engaged as resident engineer on distribution works and from 1913 to 1915 as assistant water engineer to the Stockport Corporation. During the time that he was with Liverpool Corporation considerable development was carried out, including the completion of the third pipeline of the Vrnwy Aqueduct, new filters, service reservoirs, alternative draw-off from Lake Vrnwy and other important works.

The George Montefiore Prize

AT a meeting of the jury of the George Montefiore Foundation in Liege last month, awards were made for the prize competition for 1950. It may be recalled that this prize was instituted through a bequest made by Mr. Montefiore to the Electrotechnical Institute which bears his name and is attached to the University of Liege. The prize is awarded every five years, as the result of an open international competitive examination, to the best paper contributing to the scientific or technical advancement of electricity, entries being submitted either in English or in French. The awards are decided by a jury consisting of five Belgians and five non-Belgians, who, in this instance, included Mr. U. Lamm, chief engineer, A.S.E.A. works, Ludvika; Monsieur R. Langloit-Berthelot, head of the directorate of education and research, Electricite de France; and Mr. C. W. Marshall, deputy chief engineer (research), British Electricity Authority. Of the seventeen entries for the 1950 competition, none, we learn, was British. Prizes were awarded to the following:—Monsieur Ulrik Krabbe, of Denmark, for his paper "The Transductor Amplifier"; Monsieur Max Hoyaux, of Charleroi, for his paper on "Theory of the Voltage Drop in the Arc of the Mercury Vapour Rectifier"; Monsieur Emile Herman Hubert, of Liege, for his paper on "The Possibilities of Applications of Automatic Reclosing of Circuit Breakers"; and Monsieur Rene Pelissier, of Electricite de France, Paris, for his paper on "The Propagation of Transitory and Periodic Waves Along Electric Transmission Lines." The next competition will be held in 1955.

British Institution of Radio Engineers' Festival Convention

NEXT week the third and fourth sessions of the Festival Convention of the British Institution of Radio Engineers will be held at the Institute of Education, University College, Southampton. The first session of the Convention held at University College, London, under the chairmanship of Dr. Denis Taylor, on July 3rd and 4th, dealt with electronic instrumentation in nucleonics. At this session seven papers were discussed under the heading of radiation and particle detectors, beta-ray thickness gauges, radioactive tracers, self-balancing recording instruments, counting of random pulses, design of radiation measuring instruments, and millimicrosecond pulse circuits. At the second session, on July 5th and 6th, under the chairmanship of Mr. J. R. Hughes, the eleven papers on the subject of valve technology and manufacture ranged over v.h.f. triode amplifiers, cathode ray tube manufacture, dynamic measurements, quality and reliability standards in valves, image converters for high-speed photography, line scanning valves and circuits, small-signal analysis at v.h.f., vacuum technique and rare metals in electron tubes. The third session, which will be held on July 24th and 25th, will deal with radio communication and broadcasting, and the final session on radio aids to navigation will take place on July 26th and 27th.

BOOKS RECEIVED

A Century of Technology. Edited by Percy Dunsheath. London: Hutchinson's Scientific and Technical Publications, Stratford Place, W.1. Price 15s.

Metallurgical Thermochemistry. By O. Kubaschewski and E. LL. Evans. London: Butterworth Springer, Ltd., Bell Yard, Temple Bar, W.C.2. Price 35s.

Prestressed Concrete. Second edition. By Gustave Magnel. London: Concrete Publications, Ltd., 14, Dartmouth Street, Westminster, S.W.1. Price 15s.

Building and Public Works Administration, Estimating and Costing. Third edition. By Spence Geddes. London: George Newnes, Ltd., Tower House, Southampton Street, W.C.2. Price 30s.

F.B.I. Register of British Manufacturers, 1950–51. Twenty-third edition. London: Kelly's Directories, Ltd., 186, Strand, W.C.2., and Iliffe and Sons, Ltd., Dorset House, Stamford Street, S.E.1. Price 42s.

The Electrician Annual Tables of Electricity Undertakings of the World, 1950–51. Sixtieth edition. Edited by Stanley G. Rattee. London: Benn Brothers, Ltd., Bouverie House, 154, Fleet Street, E.C.4. Price 30s.

Transformer Engineering. Second edition. By L. F. Blume, A. Boyakian, G. Camilli, T. C. Lennox, S. Minneci, and V. M. Montsinger. London: Chapman and Hall, Ltd., 37, Essex Street, W.C.2. Price 60s.

Statistical Year Book of the World Power Conference, No. 5. Edited by Frederick Brown. London: The Central Office, World Power Conference, 201–2, Grand Buildings, Trafalgar Square, London, W.C.2. Price 30s.

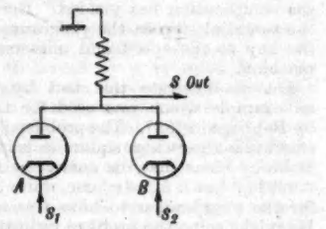
The Automatic Digital Computer at Manchester University

No. II—(Continued from page 49, July 13th)

HAVING considered, in last week's article, some of the novel components of the computer (including the high-speed electrostatic store and the main magnetic store), we now propose to examine a few of the valve circuits which have been developed for this equipment.

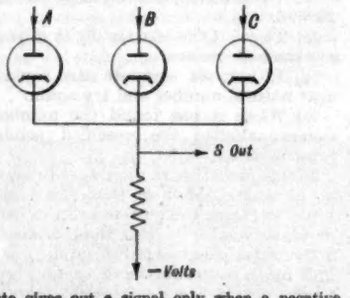
The Gate Circuits

These circuits perform the functions of an ordinary relay, that is to say, they can be opened or closed by a current flowing in one circuit, and they will control the passage of currents in another circuit. They are of two main kinds, each of which exists in several forms; some are shown in the diagrams. One kind allows a current to pass and produces a signal output if a voltage is applied to one or more of the several input terminals. This circuit is called an "OR" gate. The other produces a signal output only if there is an input on each of its terminals. This circuit is called an "AND" gate. Examples of these gates are shown in our first three diagrams.



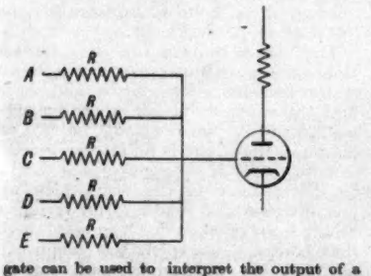
This gate gives out a signal if a negative pulse is applied to either *A* or *B*.

An "Or" Gate



This gate gives out a signal only when a negative pulse is applied to all three input terminals.

An "And" Gate



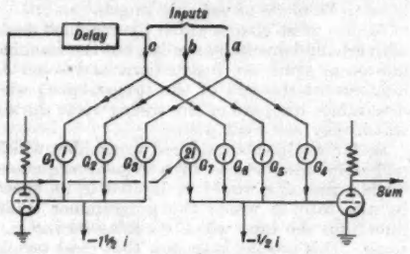
This gate can be used to interpret the output of a staticisor. The potentials of points *A*, *B*, *C*, *D*, *E* are all either +100V or −10 V. The grid is positive unless all five potentials are simultaneously negative.

Another "And" Gate

The Adding Circuit

The adding circuit, which is shown schematically in one of our diagrams, contains a number of gates, G_1, G_2, &c., to G_7, which, when opened, allow the currents indicated in the circles on the diagram to flow to and from the grids of the two valves. The gates connected to the grid are operated by the signals *a* and *b*, each of which represents a "one" in the two chains of pulses which are to be added. The signal *c* represents "ones" which are "carried" from the previous stage of the addition. A constant current of $-1\frac{1}{2}i$ is taken out of the grid of the left-hand valve, so that the total current flowing to the grid is negative if none or one of the signals *a*, *b*, or *c* is present; it is positive if two or three of them are present. The grid of the left-hand valve is normally negative, but if the current flowing to it is positive, its potential will rise, producing a signal at the anode. This signal indicates that there is a digit "one" to be carried to the next stage of the addition.

The connections to the grid of the second valve are the same as those to the first, except that the constant current which is taken from the grid is $-\frac{1}{2}i$, and that an extra gate is added, which is operated by the signal at the anode of the first valve. If two or more of the signals *a*, *b*, or *c* are present then there will also be a "carry" signal at the anode of the first valve, which will open G_7. Thus the total current flowing to the grid of the second valve will be positive only when one or three of the signals are present and under these conditions only will an output signal be produced at the anode of the second valve.



An "Adder"

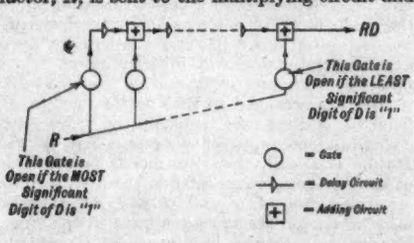
The "carry over" process is done by delaying the signal out from the "carry" anode and feeding it into the system during the next digit period.

An analysis of this circuit will show that it satisfies the laws of addition in binaries, which for convenience are given below:—

Total number of "ones" in *a*, *b* and *c*	Digit to be carried to next stage	Sum digit
0	0	0
1	0	1
2	1	0
3	1	1

The Multiplying Circuit

Multiplication is carried out in two steps, which are called for separately by the programme. In the first step one of the factors, *D*, is transferred from the main store to a register in the multiplying circuit, where it is held until it is superseded by another number. In the second step of multiplication the other factor, *R*, is sent to the multiplying circuit and multiplied by the number held in the *D* register. The product is either added to or subtracted from the contents of the accumulator. The times required for the completion of the two stages of multiplication are, respectively, 1·2 and 2·2 milliseconds.


RD
This Gate is Open if the LEAST Significant Digit of D is "1"
R
This Gate is Open if the MOST Significant Digit of D is "1"
= Gate
= Delay Circuit
= Adding Circuit

A "Multiplier"

In multiplication the factor *D* is treated as the multiplier and the factor *R* as the multiplicand. The process is one of long multiplication, in which *R* is multiplied separately by each digit of *D* and the resulting partial products added together to produce the final product. Since the factors are expressed in the scale of two, each partial product will be either zero, if the corresponding digit of *D* is zero, or *R* multiplied by a power of two (that is with its digit "shifted to the left"), if the corresponding digit of *D* is one. There are forty partial products altogether, produced from the forty digits of *D*. In the multiplying circuit these are formed in two batches of twenty, each batch being added simultaneously by nineteen adding circuits.

Since the numbers received by the multiplying circuit from the main store are expressed in serial form as pulse trains, they are multiplied by powers of two simply by delaying them; so that, for example, if a number is to be multiplied by the fourth power of two, each input pulse appears four pulse positions later in the output. In the multiplying circuit, delay circuits (each capable of multiplying by two) are alternated with adding circuits as shown in the diagram of the multiplier circuit. The factor *R* is multiplied by the digits of *D* by the gates shown at the bottom of the figure, each gate being open if the corresponding digit of *D* is one. The outputs of these gates are then injected into the chain of adding and delay circuits so that each is multiplied by the appropriate power of two as it passes through the chain.

The Staticisors

It is often necessary for the machine to "remember" for a considerable time, all the information which is contained in a chain of pulses. This is done by the use of "staticisors." Suppose one is working with a chain of five pulses. The appropriate staticisor will consist of five "flip-flop" valve circuits.

We shall denote the valves which comprise the circuits by A_1 B_1, A_2 B_2, &c. These flip-flops have two stable positions and they can be triggered from one position to the other. One valve of each pair takes all the current, which is passed by the pair, and the anode potentials of each valve is at either one or other of two definite potentials. Suppose that initially the valves A_1, A_2, &c., are passing current. The grids of these valves are all connected to a series of "AND" gates, each of which has two input terminals. The successive *P* pulses are fed to these "AND" gates, P_1 to the gate of A_1, P_2 to the gate of A_2, &c. The pulse chain, which we want to "Staticise" is fed in parallel to all the other input terminals of the "AND" gates. If the pulse chain contains a pulse in the first interval P_1 the first flip-flop will be triggered; a pulse in P_2 will trigger the second flip-flop, and so on. Suppose for example, the pulse chain is 11001. A pulse exists during the first, second and fifth *P* pulses, so the first, second and fifth flip-flops will be triggered. The flip-flops will then retain, or if we prefer to use the word, they will "remember" the information in the pulse chain until they are reset. It is convenient to say that the "dynamic" pulse chain has now been "staticised."

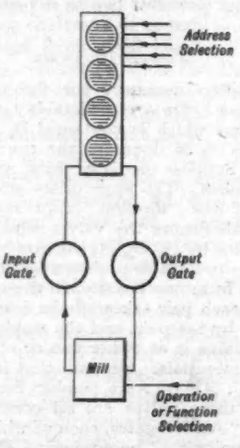
To make use of this information a steady potential is available from both the anodes of each of the five flip-flops. Suppose that, by using a suitable potential divider we make the potential of a cathode follower output stage attached to each anode, move from plus 100V to minus 10V as the flip-flops change their state. Suppose that we have five equal resistors connected from five cathode followers to the grid of another valve. The valve will pass current, and its grid will not be turned off until all the cathode followers which are connected to it are negative (see the diagram of the second "AND" gate). Now a grid carrying five resistors, each of which can be soldered to one or other of the two output cathode followers of a flip-flop can be connected up in $2^5 = 32$ different ways. This means that it is possible to connect thirty-two different valves to the cathode followers in such a way that each one can be turned off individually while all the others remain "on." Each valve can be used to control a single gate, or two or more gates if necessary, so here we have a method by which the course of one chain of pulses can

be directed through the machine in a manner prescribed by the information contained in the preceding pulse chain.

We have now described all the main components which are needed to make a machine, and we can consider stage by stage how the machine is organised.

Suppose that there are four memory tubes, each of which has thirty-two lines on it. We know that the anode potentials from a two-pair staticisor will open one of the four gates, which allow us to select the output from one of the tubes. In a rather similar way the output potentials from a five-pair staticisor set up a potential on the *Y* plates of the tubes, which makes the beam scan one particular chosen line on each tube. Any one of the 128 lines on the four tubes can, therefore, be picked out by a proper combination of the two staticisors and we recall that these staticisors will have been set up by the pulse chain which has just passed into them.

Another staticisor can be made to open the chosen gate into the "mill" or arithmetic unit and so the number selected from one line on the store can be passed through the "mill" and, after some operation has been performed on it, the result can be put back into the store. It is customary to store the result of each arithmetic operation first of all



ORGANISATION OF MACHINE

in a special line in the store, which, by analogy with an ordinary desk calculator, is called the "accumulator." The number in the accumulator can be put back into the store in a separate operation.

One cathode ray tube store is used to "control" the machine. On one line is stored the serial number of the instruction which the machine is about to obey. During the regeneration cycle of this tube, which takes place after the machine has just completed an operation, the number "one" is added to the contents of the control tube, so that the machine will usually obey a number of instructions in sequence.

The pulse chain which emerges from the control tube is used to set up staticisors, which select a particular line in the main store. This line, which contains the instruction which must next be obeyed, is then copied into a special line called the "present instruction line," which, for convenience, has been put on the control tube. The "present instruction" is then read out again and it sets up all the necessary staticisors, which open the appropriate gates, choose the number on which the operation is to be performed and route it in the correct destination.

There are four operations in all and these may be recapitulated as follows:—

1. Read the number in the control tube, add unity, and use the resultant pulse chain to set up staticisors which define the next instruction to be obeyed.

2. Copy the instruction into the "present instruction" line.

3. Re-read this information and use it to set up the staticisors which choose the arithmetic function to be performed and the number on which it is to be performed.

4. Read out the number on the chosen line and pass it through the appropriate part of the machine.

It may appear from this account that several sets of staticisors have been used in the operation but, in fact, this impression is misleading. There is, in fact, one set each of "function" staticisors, of "tube" staticisors, and of "line" staticisors, and each set is used exclusively to perform the operation which its name suggests. It is to avoid the duplication of staticisors that it is necessary to copy out the information in the "present instruction" line from the main store, which contains it, into a subsidiary store before it is used.

Analysis of the operations which have just been outlined will show that in operations (2) and (4) information from specially chosen lines is being read out. In operations (1) and (3) the main stores are not required by the machine. It is possible, therefore, to avail oneself of the opportunity and make use of the time to regenerate the main stores in sequence, line by line. It is customary to speak of the cycle of operations as a "four beat bar." Successive beats are called Scan (1), Action (1), Scan (2) and Action (2). Actual numerical computation takes place only during the last beat of a bar, which accordingly may have to be made of variable length.

All the pulse chains which the machine deals with are fundamentally similar, but the machine interprets some as instructions and some as numbers at the will of the programmer, who determines the part of the timing cycle during which they are dealt with.

So far we have considered a machine which will obey instructions in a regular sequence. Such a machine would be limited in its speed by the rate at which the programmer could punch up the tape which contains its instructions. This process is so slow that most people would prefer to use a desk calculator. How can the machine be speeded up?

In the first place it is possible to make it perform one sequence of operations several times in succession on different numbers if we:—

(*a*) Change the number in the control tube back again to that corresponding to the beginning of the sequence in question.

(*b*) Give the machine a new set of numbers to work with.

The first of the two operations can be performed by writing into the control tube the number required. Since the control tube is very like an ordinary store, we can write into it any number we please.

The second requirement can be met if, without otherwise modifying the programme, we can alter the addresses of the numbers which are to be operated on. It is so often necessary to make this change in a list of instructions that a special part of the machine has been built to facilitate it. On an extra storage tube, called the *B* tube, numbers are stored in eight lines. The use of these numbers can best be illustrated by taking an example. Let us suppose that we wish to evaluate the scalar product of two vectors, x and y, where these two vectors have been stored in two blocks in the main store—the elements occupying consecutive positions. The two orders involved in a multiplication will initially refer to the first two elements of x and y, respectively; if they are arranged so that as they are taken from the control tube to set up the order staticisors, the contents of a certain line of the *B*-tube is added, then the means is available of having these orders refer to the first, second, &c., elements of x and y without actually altering the orders as they appear in the store. For, if the *B*-tube line contains 0 initially and 1 is added to it each time we complete the cycle, the multiplication orders will refer in turn to successive elements of x and y. Return of control to the beginning of the cycle will be effected by a "transfer of control" instruction and the termination of the process will take place in a manner which we will discuss.

Our description of the machine is still incomplete; a machine which was built in the manner which we have described would be able to perform a large number of routine calculations; it would, for example, be able to work out a ballistics table if the routine could be prescribed in complete detail, as the programmer could do if he had previously worked out a similar computation by hand. It has not, however, so far been endowed with any power of independent judgment, so that if the programmer cannot foresee at every stage exactly what form the computation should take the machine cannot help him.

To overcome this difficulty it is possible to make the machine examine the content of the accumulator and take note if it is positive or negative. The machine can then be made to follow one or other of two courses of action, according to the sign of this number. The two courses of action must, of course, have been prescribed in detail by the programmer, but the choice between the two is made by the machine itself, in the light of the result which the computation has yielded. Here at last is the essential step in the programme; here is the key to the speed and universality of the machine.

Let us illustrate this fact by considering an example which was used for this purpose by Babbage in 1837. The problem is to find the smallest integer whose square ends in "269696." Babbage knew that the answer he wanted was "99736," but it is, of course, quite unnecessary for the programmer to have this information. He might solve the problem by instructing the machine to do the following:—

(*a*) To find the squares of the natural numbers in order.

(*b*) To subtract the squares in turn from 269696.

(*c*) To see if the last six digits of the number so obtained were zero.

(*d*) If not, to compute the square of the next natural number and try again.

(*e*) When it has found the number, whose square satisfied the specified condition, to print it out.

If this primitive routine were followed and it is, of course, obvious that many short cuts could be taken, the total number of instructions required would be less than a dozen, apart from those necessary for input and output. The machine would have to go through the routine 99736 times. It might take a quarter of an hour to prepare the routine, punch it and feed it into the machine; after that had been done the machine would take about another quarter of an hour to perform the requisite 99736 cycles of operations.

This same routine can also be used, as Babbage saw, to illustrate one of the limitations of the machine. Suppose we had asked it to find the smallest integer whose square ended in "269697." Now we know, but the machine does not, that there is no integer whose square ends in "7." If we were to pose this problem to the machine in the way which we have just discussed, it would go on trying until it broke down or wore out. In spite of the fact that he can now exploit the judgment of the machine, the programmer still carries overriding responsibility. The machine will slavishly perform all that he asks of it and it is up to him to make sure that the questions which he poses to it are sensible.

The art of programming is very specialised and reference to it would, therefore, be out of place in this article.

It will be appreciated, however, that there are a large number of standard operations which are likely to be required fairly frequently—e.g., binary-decimal conversion, finding the square root of a number, computing the sine of an angle, inverting a matrix, &c. If routines are made for these operations they may be stored permanently on the magnetic wheel or fed into the machine every time a programme is put in—so that they may be called down into the main store as required. It is advantageous to construct these routines so that they are as general in their application as possible; and this is best done with the aid of parameters available, for example, in standard positions in the main store. These parameters are usually

planted by the main programme and called upon by the routine during the operation.

There is one routine which is particularly important—the routine necessary for the assembly of orders presented to the input in tape or card form. This routine must be permanently available on the wheel in such a way that it is called down when the machine is started. The operation of assembling orders is not carried out by "hardware"—and, as the machine must induct a programme into itself before it can begin to obey it, it is necessary to have an initial routine permanently available to do this.

(To be continued)

The Caisson at Uskmouth Power Station

ABOUT a year ago we recorded in a Journal note that work was about to start on the sinking of what was believed to be the world's largest pneumatic caisson at Uskmouth power station, near Newport, in Monmouthshire. The sinking was recently completed, and the caisson now lies plumb and to its correct final level.

The first part of the Uskmouth power station will contain six 60MW turbo-alternators, which will be cooled by river water from the Usk, circulated from a pumping station with a capacity of 15 million gallons per hour. The River Usk has a large tidal range at this point, and as it was essential that water should be circulated at all states of the tide, the pumping station had to be sunk below the bed of the river, and was founded on the large caisson, which is described in this article.

The site of the pumping station is on the foreshore of the River Usk, and at ordinary spring tides the river level varies from +22·0ft O.D. (Newlyn) at high water to −13·0ft O.D. at low water; at neaps the range is approximately from +11·0ft O.D. to −9·0ft O.D. The substructure of the pumping station consists of a reinforced concrete building about 164ft long by 110ft wide by 80ft deep from the pump-house floor level at +28·75ft O.D. down to foundation level at −51·75ft O.D. A central wall divides the building into two symmetrical halves, each being complete and self-contained for independent operation and each containing an intake from the river, and pump, suction and screen chambers, together with a mess room and store.

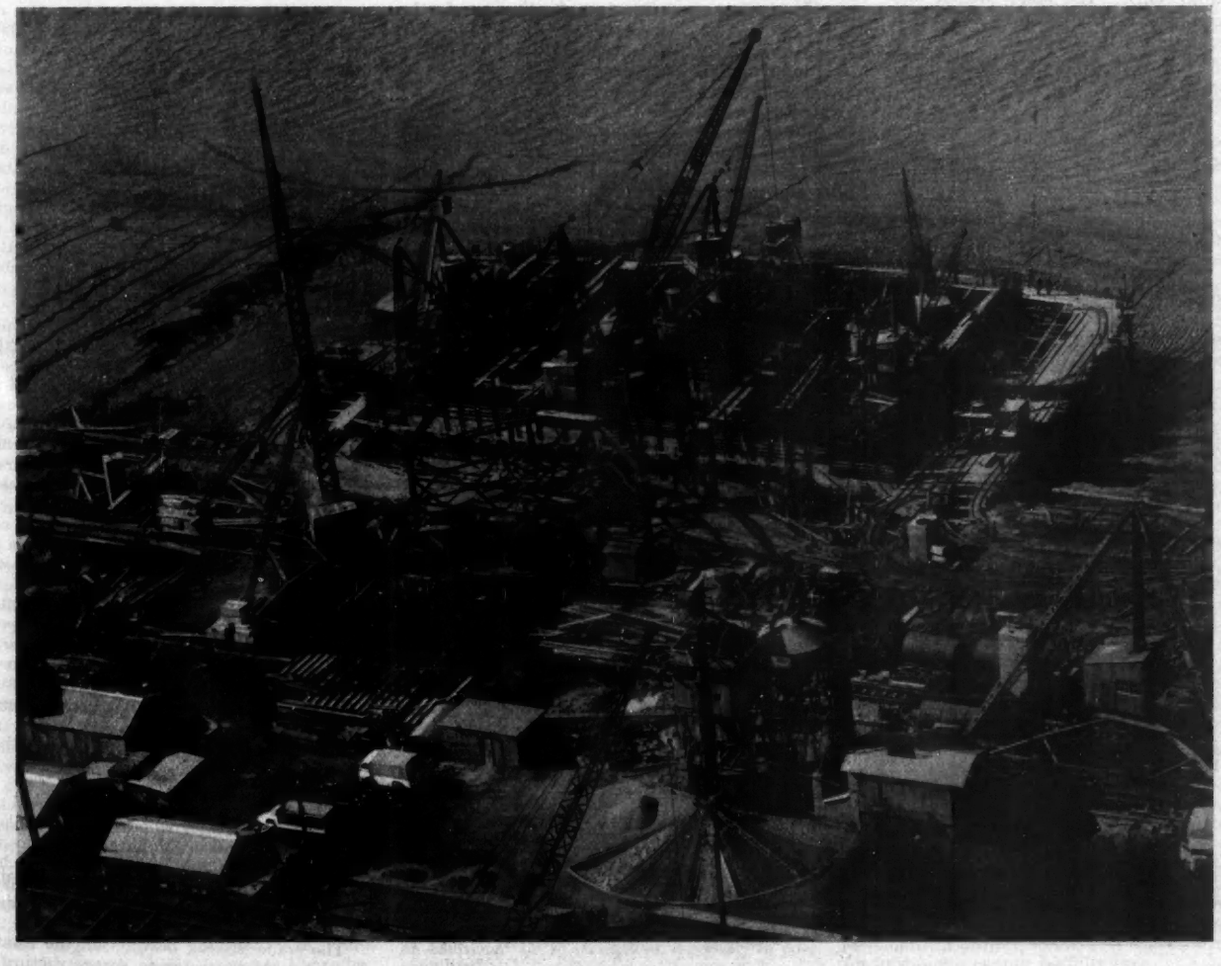
The circulating water discharge duct for the eastern half of the pumping station runs along the eastern end of the building and thence is continued shorewards. The corresponding duct for the western half runs along the west and south ends and at the south-east corner of the building turns shorewards to run alongside the duct for the eastern half, the twin duct then leading to the generating station. Along the side and ends of the pumping station the external wall of the building forms the inner wall of the duct, its outer wall being carried on reinforced concrete piles. Each duct is 9ft wide by 8ft deep and is surmounted by a cable duct of the same width and 12ft deep, the top of the latter being at a level of +28·75 O.D.

The steel caisson shoe, which is also 164ft by 110ft in plan, in addition to its peripheral cutting edge, had two internal transverse cutting edges formed on substantial spine trusses, thus dividing the steel structure into three bays. Each bay had curved roof plating carried on a system of framed trusses with hips at the corners, and formed a separate working chamber. Emergency access passages connecting the chambers were provided through the spine walls. The height of the crown of the roof plating above the cutting edges was about 12ft and the height of the external side plating was 21ft. Altogether, the caisson steelwork, which was of welded construction throughout, amounted to about 510 tons. Two air shafts terminating in combined man and material air locks were provided for each working chamber. Each material lock was served by a fast 2-ton electric derrick on a steel gabbard anchored to the concrete slab over the roof of the working chambers.

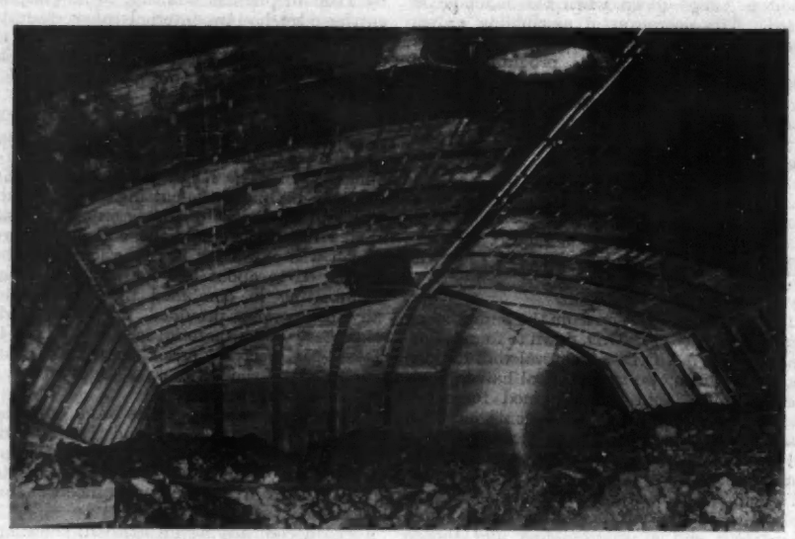
Temporary timber jetties were constructed to give access to the ends and river side of the caisson during sinking and to carry Decauville tracks for conveying away the material excavated from the working chambers as sinking proceeded.

The accompanying illustration, showing the sinking in progress, gives a good idea of the site and the plant necessary for the work. Our second illustration shows the interior of one of the three working chambers, and shows the access shafts, high-pressure and low-pressure air-lines and 25V lighting circuits.

Owing to the exceptionally low bearing capacity of the foreshore where the caisson was sunk, it was decided to assemble the steel shoe on made-up ground with a firm upper crust behind the bund, and then to roll it forward on ball tracks supported on spreaders and temporary timber trestles into a position directly above its final location. Its weight was then transferred to lowering gear controlled



SINKING OF THE CAISSON IN PROGRESS



INTERIOR OF ONE OF THE THREE WORKING CHAMBERS

by hydraulic jacks, and, after removing the rolling tracks and trestles, it was lowered on to a prepared bed consisting of some 6ft of tipped brick and stone rubble levelled off and consolidated. The rubble bed was provided to minimise any tendency which the caisson might have to tilt towards the river during the early stages of sinking. The north face of the cutting edge prior to rolling out, with the temporary timber trestles over which it was rolled in the foreground, are shown in the illustration below.

The level of the rubble bed was about +10·0ft O.D. The steel caisson shoe was lowered on to the bed on a day when high-water level was insufficient to float it, and when succeeding tides were diminishing for the next few days. Concreting of the cutting edge haunches and the slab over the steel roof of the working chambers was carried out as expeditiously as possible in order that sufficient weight was added to prevent flotation during the next series of spring tides. Sinking by excavating in the working chambers then proceeded at the same rate as the building up of the concrete walls and partitions of the pumping station structure. The level of the top of the concrete walls was kept at about +30ft O.D. to prevent possible flooding by an exceptionally high tide.

In general, concrete was pumped through pipe-lines from a mixing station situated some 150ft south of the caisson site. During sinking the openings from the river to the intake culverts were temporarily plugged with brick panels 4ft thick. On reaching formation level the sinking weight was in the region of 40,000 tons.

At the present time the main structure has been founded and the working chambers concreted and sealed, and a temporary "patch" cofferdam of steel sheet piling, 75ft long by 22ft wide, is now being driven against it around the intake. The external screens, and the intake gates, together with their guides, fixings and access ladders, will be assembled inside this cofferdam, and the brick plugs covering the intake openings demolished and removed. At the same time, work on the discharge ducts will proceed. Finally, the steel framework of the superstructure of the pumping station will be erected, and the overhead travelling cranes for handling the pumps and machinery installed. Dredging of the river at the intake approaches is being carried out under a separate contract.

The Uskmouth power station is being constructed for the British Electricity Authority, the consulting civil engineers for the work described in this article being L. G. Mouchel and Partners, and the contractors responsible for sinking the caisson being Holloway Brothers (London), Ltd.

CAISSON CUTTING EDGE

A Repair Control System

A VISUAL control system by Remington Rand, Ltd., Commonwealth House, London, W.C.1, has been installed in the truck service progress department at Rootes, Ltd., Ladbroke Hall, London, W.10. The object of the installation is to show the progress of each vehicle or unit, such as rear axle, gearbox or engine, under repair. From the visual information supplied the progress department can keep all repairs under continual observation, no matter what stage they have reached, and it requires only one operator to keep the entire system up to date.

Immediately each vehicle, or unit, enters the depot a copy of the instructions to the works is sent to the progress department, showing the date the customer requires the vehicle and the nature of the repairs to be carried out. A card representing the vehicle is then made out, which is placed according to the day on which it comes in for repairs. The vehicle's course is then "tracked" until it is ready for delivery to the customer.

Extraordinary circumstances are provided for, such as the inability to obtain parts, in which case the vehicle becomes overdue and is transferred to the appropriate section of the panel. Coloured signals are used here to give more positive control.

Track-Laying Cranes

SEVEN of ten new 8½-ton diesel-electric cranes for track relaying work have been delivered to the London Midland Region of British Railways and are now in operation. These cranes, working in pairs, can be used to take up and relay up to a mile of track in a day.

It will be remembered that this method of track relaying was started in 1946, when the former L.M.S. started to lay 60ft lengths of pre-assembled track with 10-ton capacity diesel cranes, which have been in service since 1939–40, and by 7-ton steam cranes. In view of the satisfactory results obtained it was considered that if an appliance was specially designed for the work a considerable speed-up could be achieved with consequent economy in operation. For this reason an outline design of a diesel-electric rail travelling crane was formulated by Mr. H. G. Ivatt, C.M.E., London Midland Region, in collaboration with the civil engineer, and a specification was prepared for a crane which would be able to hoist 8½ tons at 15ft radius at 50ft per minute with the crane free on the track, falling to 2½ tons at 33ft radius at 110ft per minute.

In addition the crane had to be capable of hoisting 8½ tons at 18ft radius, falling to 3½ tons at 35ft radius when blocked up, and to slew 8½ tons at a speed of 2 r.p.m. The full range of the jib had to be operated, in or out, in thirty seconds, and the crane had to travel at 3 m.p.h. with an 8½-ton load and have sufficient power to climb a 1 in 40 gradient drawing three loaded wagons, and to be capable of travelling in train formation at speeds up to 45 m.p.h. and to negotiate four-chain curves slowly. The axle load of the crane in train formation was limited to 17 tons, and it was to have stability in accordance with B.S. Class "B" requirements, which had to be maintained on a 4in super-elevated track. An important factor was that the tail radius of the rotating superstructure was not to exceed 5ft, so that the crane might operate with a minimum of obstruction to adjacent structures and to passing traffic.

A contract for ten cranes was let at the end of 1947 to Taylor and Hubbard, Ltd., Kent Street, Leicester.

The engine/generator unit at one end of the crane undercarriage, which is removable as a whole, comprises a McLaren Ricardo three-cylinder diesel engine, developing 82½ b.h.p. at 1100 r.p.m., directly coupled to a Lancashire Dynamo and Crypto 280V, 54kW, compound-wound generator.

The crane driving position on the front left-hand side of the rotating superstructure gives

the driver a good view of the load at all times. Immediately in front of the driver are the four contactor controllers, and the usual controller operating crank handles have been replaced by a fore-and-aft lever movement, via bell cranks and bevel quadrant with four upright levers for the hoist, slew, derrick and travel motions, arranged directly in front of the driver.

Series-wound hoist, derrick and slew motors in the superstructure drive their respective motions through totally enclosed David Brown worm reduction units, the two former motions having a train of double helical machine-cut gearing interposed between the worm units and the wire rope barrels.

Electro-mechanical solenoid brakes are fitted to the hoist and derrick motions, the hoist brake having hand release from the crane driving position. The slew and travel brakes are of the foot-operated band type.

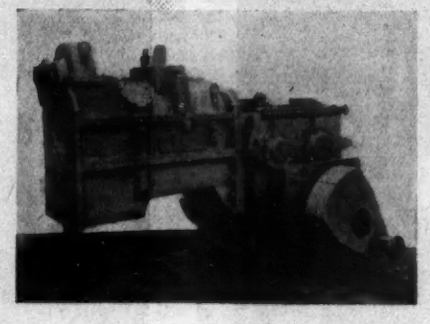
Diesel Industrial Locomotives with Hydraulic Transmission

In our issue of June 1st, last, we gave some particulars of the "North British Miner" diesel mine locomotive, fitted with hydraulic transmission, which is being made by the North British Locomotive Company, Ltd., of Springburn, Glasgow. We are now informed by the company that it has completed the first of a series of shunting locomotives which incorporate the Voith-North British hydraulic transmission. This locomotive, illustrated below, is a 200 h.p., 0–4–0 unit weighing 32 tons, and it is designed for general yard and railway duties. It has a tractive effort of 21,500 lb, and is designed for a maximum speed of 12 m.p.h. With its short wheelbase of only 6ft, it is suitable for all types of medium shunting work, and we are informed that other locomotives of 300 h.p., 500 h.p. and 600 h.p. are being built for shunting and main line duties.

200 H.P. DIESEL HYDRAULIC LOCOMOTIVE

In this new locomotive the transmission is built as a unit with the final drive and reverse gearbox, and the driver's controls are limited to throttle, reverse lever and brake. There is no change-speed gearing nor clutch, and the change from one hydraulic circuit to the next, up or down, is completely automatic. The transmission is engaged on the opening up of the throttle through mechanical linkage from throttle lever to the oil supply pump. The change-over from one stage to another is dependent only on the road speed and is controlled by a mechanical governor driven from the output shaft. This governor therefore selects automatically the circuit which is to be engaged, and controls the output of the engine.

In the transmission unit there are three hydraulic circuits:—a torque converter for starting and low speeds, and two fluid couplings, one for the medium and one for the higher speed ranges. In each circuit, the input shaft drives an impeller, which acts as a pump, imparting energy to the oil in the circuit and driving a runner, which is geared to the output shaft. While the engine is idling, the transmission is disengaged. Movement of the throttle lever away from the idling position opens a filling valve in the delivery line from the pump, situated in the sump, which supplies oil to the driving circuits, and the governor directs the oil to the converter. When



HYDRAULIC TRANSMISSION UNIT

the throttle is opened and the locomotive has gathered speed, the action of the governor fills the first coupling and empties the converter at a predetermined road speed. As the speed of the locomotive continues to rise the governor directs the oil into the second coupling, also at a fixed road speed, emptying the first coupling.

If greater resistance is encountered when ascending a gradient the governor automatically cuts out the top speed coupling and fills the intermediate coupling. A filling valve lock is provided in the driver's desk by which the valve can be locked in the closed position, and the engine can then be run up independently without moving the locomotive.

The oil circuits are engaged and disengaged smoothly and concurrently so that the flow of power is steady and uninterrupted while the load is being accelerated. It is not necessary to reduce the engine speed manually nor to provide for clutching operations, and the uninterrupted acceleration allows the maximum speed to be attained rapidly.

The locomotive is fitted with a Davey Paxman 6 R.P.H. six-cylinder, four-stroke diesel engine, which has a continuous rating of 200 h.p. at 1000 r.p.m. The fabricated main frame of the locomotive is built from heavy section steel plates. Easy access is provided to the engine compartment for inspection and maintenance purposes through doors on each side of the superstructure, which can be renewed as a complete unit if necessary.

Driving controls, comprising throttle and brake, are duplicated on each side of the cab, and an excellent view is given in both directions through the large windows. An air compressor belt driven from the engine, supplies low pressure air for the brakes, sanding and horn. The battery is charged by an engine-driven dynamo through a regulator and cut-out, and the engine is started by a C.A.V. electric starter motor. The engine start and stop controls are combined in a single lever.

RADAR FOR BRITISH RAILWAYS' VESSELS.—The Railway Executive announces that all seagoing vessels, passenger and cargo, belonging to British Railways' fleet will shortly be fitted with radar, as an additional aid to navigation, especially in poor visibility.

National Coal Board's Anthracite Project

ON Tuesday, July 17th, the National Coal Board announced approval of a project for a new anthracite colliery costing £7,500,000 in the Gwendraeth Valley, in No. 1 (Swansea) Area of the South-Western Division. The colliery, which will be at Cynheidre, about 5 miles north of Llanelly, is designed for the production of one million tons of saleable coal a year. Plans have been in course of preparation for a considerable time, but before deciding to sink new pits and develop a colliery undertaking on completely modern lines it was necessary to obtain first-hand evidence of the incidence of the seams by means of a borehole at Sylen. On May 25th it was announced that after boring to a depth of 2550ft at this point the Big Vein, one of the best anthracite seams in the South Wales coalfield, had been struck. This seam and neighbouring seams are continuous with those now worked nearer the outcrop to the west and to the north of Cynheidre. Other bore-holes have to be put down to complete the planning of the underground lay-out of the colliery, but from a geological point of view sufficient is now known about the coal reserves to justify the scheme.

The estimated expenditure in relation to the estimate of output is extremely high. The anthracite field is considerably disturbed geologically; mining conditions are far from favourable and because of factors in the historical background the costs of production in the anthracite field of South Wales are by far the highest in the country. However, the anthracite obtained from the new project will be won at less cost, quality for quality, than from most of the neighbouring pits.

The new colliery will lie 3 miles south-west of Great Mountain No. 3 Pit near Tumble, at the northern end of the Gwendraeth Valley. The necessary land has been purchased and consultations have been held with British Railways in the matter of railway and siding accommodation; the rail connection is to the Mynydd Mawr railway line. Workable reserves in seven seams of the best type of anthracite are estimated at more than 100 million tons, of which 17½ million lie in the Big Vein alone. All the seams to be worked lie within 750 yards of the surface at the point where the shafts will be sunk and the average anticipated thickness of each is put at Big Vein, 8ft; Green Vein, 2ft 9in; the Hwch, 10ft; the Gras, 2ft 6in; the Braslyd, 2ft 4in; the Gwendraeth, 2ft 10in; the Pumpquart, 3ft.

Production of coal in the new colliery is expected to begin in 1956; full output will be reached by 1962. One shaft will be 24ft in diameter and the other 20ft; they will be sunk to depths of approximately 2280ft and 2080ft. The shaft at Great Mountain No. 3 will be incorporated in the scheme and used to augment ventilation. Horizon mining will be practised, as at Nantgarw, Llanharan and other development projects in South Wales, the seven seams being worked from four horizons at vertical intervals of 200ft. While the Gwendraeth shafts are being sunk the development of these horizons will begin from Great Mountain No. 3. The proposed method of lay-out will be the most suitable for coping with geological uncertainties and for obtaining efficient production. Wherever practicable, the system of mining will be "advancing longwall" served by locomotive haulage and mine cars. The colliery is being planned as an all-electric undertaking, taking power from the South Wales Electricity Board.

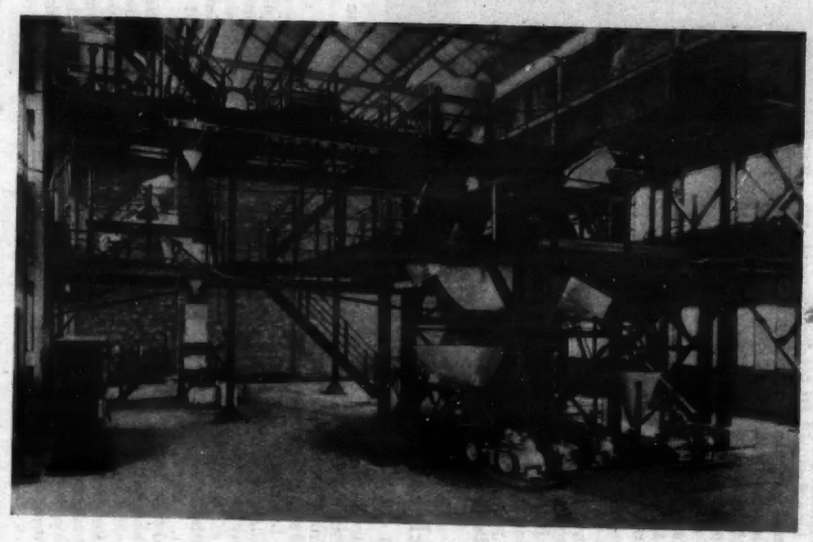
Eventually the colliery should provide employment for about 3450 men. This is 600 more than the total number now working at six neighbouring collieries, most of which are approaching exhaustion. The project therefore provides security for all the men at those collieries, who would otherwise be faced ultimately with the problem of redundancy. The Board feels justified in launching this great development project because the inland demand for anthracite cannot be fully met.

RESEARCH AND DEVELOPMENT BUILDINGS OF THE SIMON ENGINEERING GROUP

COAL CRUSHING ROOM

FUEL LABORATORY

ANALYTICAL LABORATORY

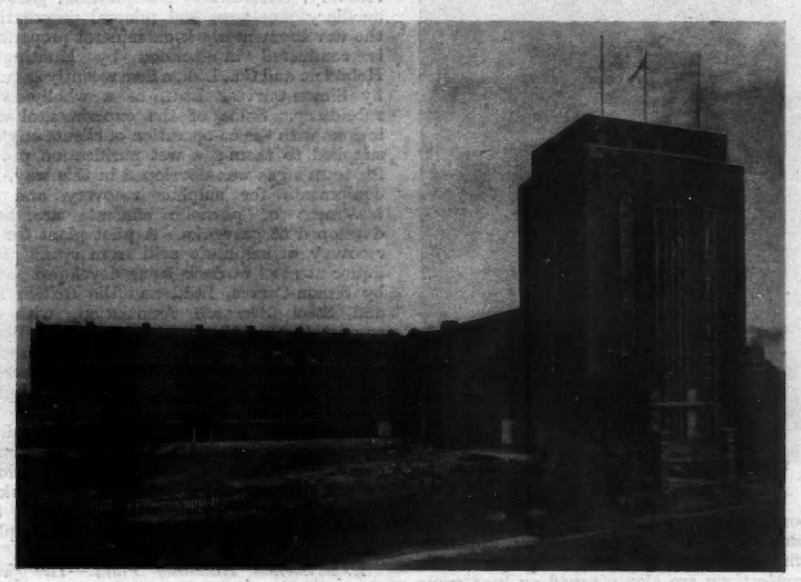


DENSE MEDIUM COAL WASHING PLANT

Simon Engineering Group Research and Development Buildings

LAST week we had the pleasure, in company with a large number of other guests, of visiting the new research and development buildings of the Simon Engineering Group at Cheadle Heath, Stockport. In the accompanying engravings we illustrate these large and well-appointed buildings.

The firms within the Simon Engineering Group, including Simon-Carves, Ltd., Simon Handling Engineers, Ltd., Henry Simon, Ltd., and Turbine Gears, Ltd., made a wide variety of products, including coal-preparation plant and colliery surface equipment, coke-oven and gasworks plant, boilers, chemical plants, pneumatic and mechanical handling plants for grain, coal and other materials, warehouse equipment, flour mills and other similar plant, and gears and gear units. Many of their clients, by constructive criticism of tenders and by allowing access to their plants for operational study, have given valuable help in design and development. Help also has been received from the research laboratories of universities and industrial associations. But it was felt that none of these existing external sources of new knowledge and ideas could really relieve the Simon organisation itself of the need to conduct its own specialised researches into matters of particular interest to itself and its clients. For, after all, the firms within the group bear the ultimate responsibility for the success or failure of their plants, some of which are very large and costly, and some of which, too, are installed many thousands of miles away. Hence, it was decided that laboratories specially arranged to meet the requirements of the group should be built, and by erecting the laboratories a large number of pre-existing, but separate laboratories and experimental plants, formerly scattered over the 80-odd acres of Cheadle Heath property have been centralised in the single block of buildings that we illustrate. The work done, and to be done, in the research laboratories covers the fields of coal cleaning, coal carbonisation, treatment of coal by-products, fuel combustion, steam generation, sulphuric acid production, gasworks ancillary processes, electrostatic precipitation, pneumatic and mechanical handling of bulk materials, and all phases of flour and provender milling engineering.



RESEARCH AND DEVELOPMENT BUILDINGS

Research

Some of the problems now being investigated in the new buildings concern specific domestic aspects of well-known fields of research, while others lie in new fields; some relate to the activities of the company as a whole, while others are of purely departmental interest.

One field of common interest is the behaviour of small particles, with special reference to sedimentation, the collection, extraction and disposal of industrial mists and dusts, pulverisation of coal, combustion of pulverised fuel and sulphur-bearing ores, and magnetic properties. The problem is complicated by the fact that the particles involved are not of uniform density, a difficulty which applies to certain aspects of electrostatic precipitation, to assessments of boiler flue dusts, and to the determination of the stability of dense media in coal-washing baths. Dense medium coal washing calls for a fundamental study of the magnetisation and demagnetisation of such particles, and there is need to develop methods of identifying and analysing the magnetic constituents of ores.

A major problem at present is the supply of sulphur for sulphuric acid production, and among the sources under consideration are recovery from waste gases and flue gases, removal as hydrogen sulphide from town's gas, and the flash roasting of iron pyrites. Interest is also being maintained in the microbiological process. Further study is required on certain aspects of the problem of effluents from gasworks and coke-oven plants, and there is ample scope for work on the corrosion resistance of metals used in plant construction.

More fundamental or long-range in character are the study of heat and mass transfer coefficients to provide absorption data for sulphuric acid manufacture, and the study of the electrical factors in electrostatic precipitation, with special reference to migration velocities, the wave form of applied potentials and corona discharge.

Mechanical and Chemical Testing.—In a business so largely concerned with various forms of coal preparation and utilisation, exhaustive coal tests are essential in determining plant design and performance guarantees. No less than nine laboratories, with ancillary rooms, are devoted to the preparation of samples, "washability" tests, and examination of the coking qualities of coals for carbonisation, and of the calorific value, ash fusion and grindability of coals for boiler firing. Extensive facilities are also provided for testing the refractory materials used in coke ovens and boiler combustion chambers, and for metallurgical tests (including heat-treatment and microscopic examination) of the metals used in plant construction. Building materials are also subjected to test.

There is a large analytical laboratory for general chemical analysis.

Milling Research

Much of the work being done in the new laboratories is applicable, generally, by all the units in the Simon Engineering Group. Some, however, is related to the particular activities of a particular unit of the group. For instance, to meet the needs of Henry Simon, Ltd., there is a group of laboratories equipped with special apparatus to meet the needs of flour milling research.

The work includes the study of new flour milling processes and of the fundamentals of existing methods of grinding, separating and conveying mill stocks. Typical problems involve the mapping of air distributions, examination of the composition and behaviour of moving streams of particles, conveying of particulate matter, dust filtration, the specification and testing of new types of bolting cloth, and the study of grain-cleaning processes. Special use is made of optical, photographic and electrical techniques. There is, too, a flour-treatment laboratory equipped with specialised apparatus for testing the ash content, moisture content, particle size and colour of flour, the special properties of self-raising flour, and the strength and gluten content of dough; test milling of wheat can be done on a laboratory scale, and complete baking tests can be made; there are also facilities for examining problems of insect infestation. The main functions of the laboratory are the checking of the performance of new types of machines by analysis of their products, the provision of a consultative analytical service for flour millers, the development of improved types of flour mill laboratory apparatus, and the provision of a basic laboratory training service for trainees and student millers.

The tower that forms the most conspicuous feature of the new buildings contains a plant (arranged as in a commercial mill, on six floors) on which grain-cleaning and flour-milling operations can be performed on full-size commercial machines. New processes and the performance of new equipment can be tested on a practical scale. A low-pressure pneumatic conveying system is an important part of the plant. Besides its function as a development and testing unit, the mill also serves as a working showroom.

Development Building

The work of the development department falls into two general categories. The first involves new principles and the study of new processes from the laboratory through pilot plant stages of increasing size; the object of the early stages is usually to gain data on the operation of individual units of plant, from which successively larger units are designed, while in the later stages the units are integrated into a complete plant. The second category involves no new principle, but calls for a study of the operating characteristics of existing full-scale plants, the results being applied to the design of future installations or the modification of those already in use.

The erection of pilot plants for the study of new processes is provided for by the development building. The pilot plants are designed so that they can be modified or replaced as occasion demands; certain plants may become permanent when the basic design and operating characteristics have been established, and they can then supplement the work of the testing laboratories by serving as large-scale test units in which clients' materials can be processed.

Site investigations on commercial plants are

facilitated by a mobile laboratory fully equipped with test apparatus and instruments.

It is intended to instal in the development building a combustion pot to determine the behaviour of solid fuels on travelling grate stokers and spreader stokers, and a new type of pulveriser, which will be used for extensive tests on coal pulverisation when the characteristics of the pulveriser itself have been established.

The effects of ammonia, oxygen and carbon dioxide in boiler feed water are to be investigated on a pilot plant scale in the research

REFRACTORIES CRUSHING ROOM FOR PRODUCING TEST PIECES

laboratories. Problems of carry-over are examined at sites, a measuring apparatus having been developed for this purpose. Site investigations are also planned on heat transmission in combustion chambers with the aim of determining the optimum spacing of tubes. Flow distribution and resistance in water-tube boilers will be investigated in a test rig in the development building. Another test rig in the development building is planned for experimental work on the most effective type of expanded joint for high pressures. Certain practical work in this field has already been accomplished.

Coke-Oven and Washery Department.—The development building at present houses three pilot plants in various stages of development.

There is a coal-washing plant employing a magnetic dense medium prepared from blast-furnace flue dust. It incorporates a magnetic medium cleaning system, much of which is novel and has been developed from investigations on separate small-scale units. The washer, which is fully mechanised to treat up to 20 tons of coal per hour, now represents an advanced stage in the integration of units into a working pilot plant, and when current investigations are complete it will be retained as a standard test unit.

The coke-oven plant is already a test unit, development having been completed some years ago. The oven can carbonise 10 cwt of coal and the results can be correlated with those of full-scale practice; the unit incorporates coal-crushing and blending plant, and equipment is available for examining the coke produced, a special feature of this equipment being an integrating radiometer for establishing the combustion characteristics of domestic coke.

The pilot distillation plant exemplifies the early stages in developing a new process, of which the basic operating characteristics are now being studied on a "100-gallon" scale. The fractionating column is of an entirely new design, which shows promise of giving high efficiency in small volume. Plants or units of plant have already been erected, tested, and dismantled after the completion of experimental operation, and others are contemplated.

The work done on existing full-scale plants comprises the execution of guarantee and performance tests on coke ovens and coal-washing plant, the investigation of pressure relationships in coke ovens, the determination of shrinkage characteristics in coking coals, and the establishment of heat and material balances in coke-oven by-product plant.

Chemical Plant Department.—Short-term studies are often called for on problems of local requirements at the site of some particular full-scale plant. When practical tests are needed, laboratory experiments are normally adequate; these are carried out with the collaboration of the research department.

Long-term work is undertaken on the development of process equipment for sulphuric acid production by the contact process, sulphuric acid recovery and concentration, sulphur recovery, electrostatic precipitation, gasworks ancillary processes, and mineral preparation; the development work on mineral preparation is conducted in London by Huntington, Heberlein and Co., Ltd., a firm recently acquired by Simon-Carves, Ltd., as a wholly-owned subsidiary. Some of the experimental work is done with the co-operation of clients on plant supplied to them; a wet purification process for town's gas was developed in this way, and equipments for sulphur recovery and the treatment of phenolic effluents are being developed at gasworks. A pilot plant for the recovery of sulphuric acid from spent pickle liquor at steel works is being developed jointly by Simon-Carves, Ltd., and the British Iron and Steel Research Association, with the co-operation of the Steel Company of Wales, Ltd.; it is probable that certain features of the process will be examined in the development building before a complete pilot plant is built in South Wales.

Other long-term projects will be carried out with apparatus installed in the development building. A test assembly of axial cyclones for gas cleaning will be operated, and work on the electrostatic precipitation of dusts and mists will be undertaken later at the pilot plant stage.

Experimental Handling Plant.—The prime purpose of the pneumatic and mechanical handling plant in the development building is to examine the possibility of pneumatically handling the many industrial bulk materials hitherto considered too "difficult." The main problems are, first, to move the material, and, secondly, to separate it from the air stream. It is also important to examine the behaviour of difficult materials in storage bins. In resolving these problems certain fundamental data on particle size, terminal velocity, angle of repose, &c., are obtained, and thereafter theoretical conclusions are tested by full-scale experiments.

The test plant comprises a full-size pneumatic intake and handling system with various types of air filter, this being integrated with mechanical handling equipment, automatic weighers, small storage bins and a sacking-off spout. Material for testing is pneumatically discharged from road vehicles, after which it can be weighed, circulated pneumatically and mechanically, sacked-off, discharged into and extracted from bins, and loaded back into road vehicles as required.

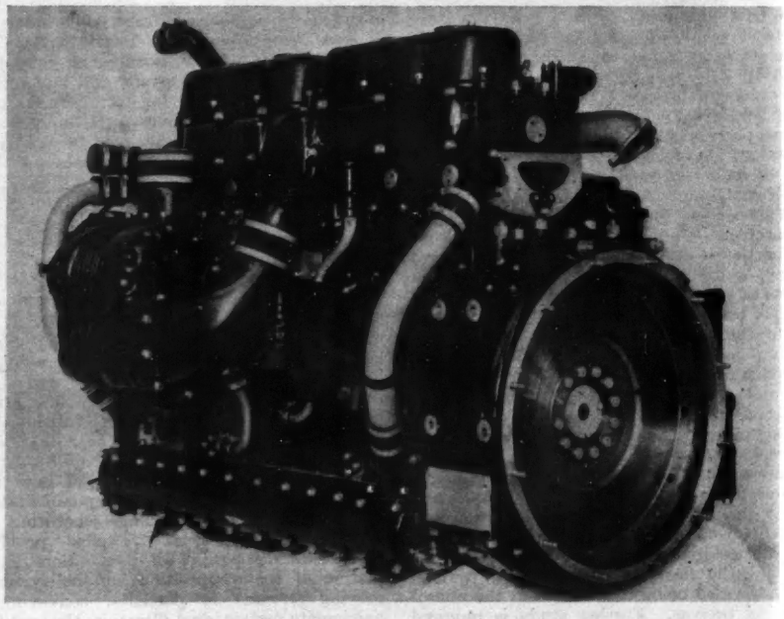
The plant is also largely used for testing newly developed items of equipment, which can be readily incorporated in the system.

A Range of Diesel Engines

SEVERAL years ago Rolls-Royce, Ltd., decided to develop an oil engine suitable for earth-moving equipment, and that company recently announced that production of a range of oil engines has now commenced, for which purpose a separate division had been created, housed in a new factory adjacent to the main works at Derby.

Intensive development has been carried on, commencing with single-cylinder units. 15,000 to 20,000 engine hours have been accumulated on the test bed, and many hundreds of hours in vehicles. A number of engines have been fitted to Vickers V.R.180 crawler tractors which have carried out intensive work on various kinds of sites. The range of engines to be produced is intended to cover earth-moving equipment such as crawler tractors, dumpers, power scrapers and graders and all types of oilfield equipment within its horsepower range. It is also intended that the engines shall be adapted for marine use.

All engines in the present range work on the four-stroke cycle and are either four or six-cylinder engines. They may be normally aspirated or supercharged and the specifications provide for either wet or dry sump lubrication and for either light alloy or ferrous



SUPERCHARGED OIL ENGINE

casings, according to whether weight-saving is a controlling factor in the particular units in which they are installed.

One particular engine, which is illustrated herewith, is designated the C.6.S.F.L.; it is a six-cylinder, direct-injection, supercharged unit fitted with overhead valves, and is liquid-cooled. The bore is 5½in, and the stroke 6in, giving a capacity of 12·17 litres. At the governed engine speed of 1800 r.p.m., the engine develops 190 b.h.p. and the relatively flat torque curve indicates a maximum torque of 600 lb ft at 1260 r.p.m. The net dry weight of the engine is 2480 lb.

The crankcase is designed so that the wheel-case and flywheel housing can be fitted to either end. By this means the exhaust system, supercharger and other units, can be fitted on either side of the engine for "handing," without any alteration to the fully machined crankcase casting. The cylinder-block is integral with the crankcase and has "wet" liners, whilst press fit replaceable valve seats are used in the cylinder head. A seven bearing crankshaft incorporates, at the front end, an externally mounted torsion damper, using viscous silicone.

Each of the light alloy pistons is fitted with three compression and one oil scraper ring, the combustion chamber within the crown being of toroidal form. The gudgeon-pins are pressure lubricated through holes drilled longitudinally in the connecting-rods. Mounted on the crankcase is a supercharger working on the positive displacement principle and driven from the timing gears at approximately twice engine speed. At 1800 r.p.m. a boost of about 8 lb per square inch is obtained.

A heat exchanger is used to maintain the engine oil at a constant temperature.

On starting the engine the cooling radiator is by-passed, the coolant then recirculating through the heat exchanger chamber and engine. This chamber, located on the side of the sump, contains three pairs of tubes through which the cold lubricating oil makes three passes, surrounded by the warming coolant. When the coolant reaches 70 deg. Cent. the automatic thermostatic control opens and allows the coolant to circulate through the radiator.

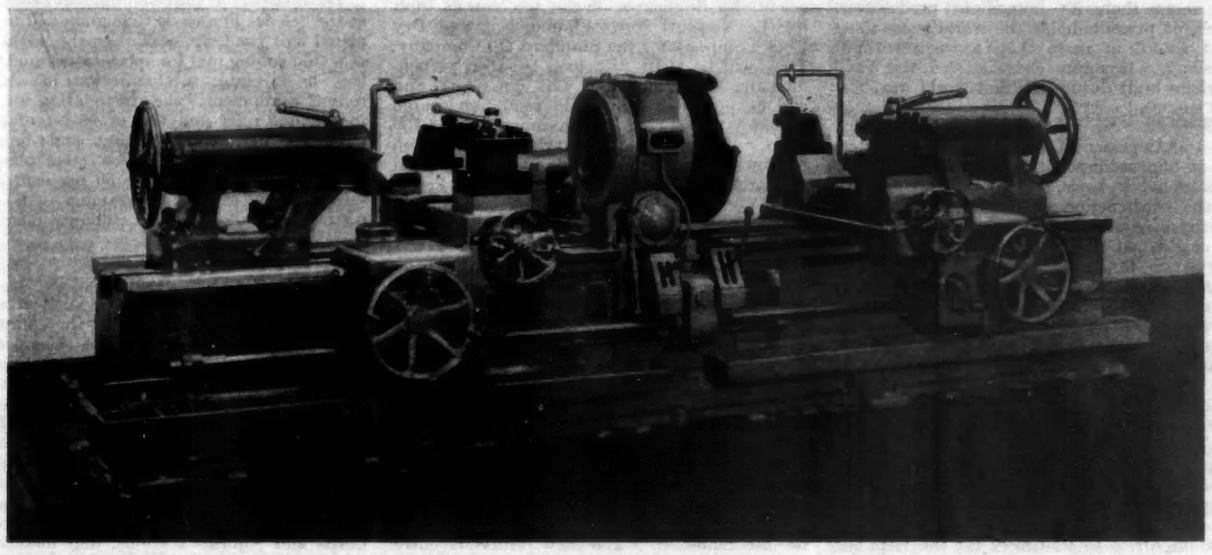
Normally the wet sump system of lubrication is utilised but if use on uneven ground is anticipated, the dry sump system may be employed. Dry sump lubrication with an oil reservoir makes the engine suitable for working on inclines of up to 40 deg. As the oil drains into the sump it is pumped through strainers and a deaerator, into the reservoir. The oil is then pumped through the heat exchanger, from which it passes through full flow filters to the main feed gallery for the engine bearings. Full pressure lubrication is maintained at 40 lb per square inch, whilst oil at a lower pressure is supplied to the rocker-shaft bearings, the push-rod ball ends and the ends of the valve stems. The coolant is circulated by a belt-driven centrifugal pump through the heat exchanger, engine and radiator. Provision is made for fitting twin cooling fans.

A 24V starter motor and the generator are the only electrical units on the engine.

A 16in Axle Lathe

Our illustration shows a 16in axle lathe for the Canadian National Railways which has just been completed and dispatched by Tangyes, Ltd., Smethwick, Birmingham. The details required in the specification necessitated an almost complete redesign of the standard machine. Its completion within the agreed period of five months compares with the normal time of about twelve months. The specification required an extra heavy-duty design for rough and finish turning journals and wheel seats of carriage and wagon axle forgings, and for finish turning and burnishing, both ends being operated simultaneously. To meet these requirements hardened steel or bronze wear strips are fitted to all bedways, and oversize tailstocks have been fitted with built-in anti-friction centres and loading supports. Hardened and serrated bases now replace the dowel location of the tool turrets.

The leading particulars of the machine are: height of centres 16in; swing over bed 30½in; and maximum distance between centres 8ft 6in. There are eight spindle speeds between 10–90 r.p.m., and feed rates of up to $^{7}/_{32}$in per revolution.



16in Axle Lathe

Tungsten.—The Ministry of Materials announces that it will become the sole importer and distributor of tungsten ores and concentrates as from July 30th next. Shipments licensed for import and already sold to consumers will not be affected by these new arrangements. A further announcement, describing the arrangements in more detail, will be made a few days before they come into effect.

Motor Trade Summer School.—The Institute of the Motor Industry (Inc.) is this year holding its fifth annual summer school from August 25th to September 1st at St. Catharine's College, Cambridge. Within the syllabus are two main courses. Course A provides an option of three main subjects: costing, legal aspects, and economic and industrial relations. The subjects in Course B can be chosen from either the practice of management or the principles and practice of sales promotion. The subjects themselves are sub-divided and a considerable choice of matter is provided. Further details may be obtained from the secretary at 40, Queen's Gate, London, S.W.7.

American Engineering News

(From our American Correspondent)

Construction of a Large Gas Turbine

An order has been placed with the Westinghouse Electric Corporation, South Philadelphia, Pennsylvania, for the construction of the largest gas turbine-generator yet ordered for the commercial generation of electric power in the United States. The unit, a 15,000kW machine, will be installed in the Bartlesville area of the Public Service Company of Oklahoma. Natural gas from the Oklahoma fields will provide the fuel for the turbine. It is scheduled for delivery in about three years. The turbo-generator installation will consist of the gas turbine as the primary source of power, driving a hydrogen-cooled generator. The gas turbine unit operating at 1350 deg. Fah., will comprise high and low-pressure turbines driving high and low-pressure compressors, respectively, with the high-pressure turbine also connected to drive the generator. Intercoolers will reduce the temperature of the compressed air between stages of compression and a regenerator will give exhaust-gas heat to the air before it enters the combustor, to reduce fuel consumption.

A Propeller for Airships of the U.S. Navy

A new propeller, known as the "Zep-prop," has been developed by the Curtiss-Wright Corporation, of Caldwell, New Jersey, and is expected to play an important part in the programme of the U.S. Navy to increase further the demonstrated effectiveness of lighter-than-air craft as submarine hunters and destroyers. Equipped with a special transmission, which enables blimps of the U.S. Navy to back-up in flight and to hover in a stationary position, the propeller is stated to add ease and precision of control to the long-range, sustained-flight advantages of lighter-than-air craft for anti-submarine defence. Two of these Curtiss-Wright propellers have been installed by the U.S. Navy in the Goodyear "ZPN" blimp, which is now being prepared for flight tests by the Goodyear Aircraft Corporation, at Akron, Ohio. Due to the quick-responding, electrically-operated transmission built into its hub, the "Zep-prop" provides a considerable versatility of control. Shifting levers permit the pilot to change the angle of the propeller blades from that required for most efficient forward speed to neutral for hovering without turning off the engines, or into reverse pitch for slowing down, manoeuvring, stopping and backing-up in the air. While extended backward flights are not practical, the ability to reverse propellers makes it possible to adjust the position of the ship over a particular spot

and is a pronounced aid in making fast turns where a quick change of direction is required to keep contact with a target or to execute evasive tactics in the event of attack. As used with the Goodyear "ZPN" the propeller consists of three blades swung in an 18ft arc. The blades are of the Curtiss-Wright hollow-steel construction and are considerably lighter than equivalent ones made of aluminium alloy. The two propellers of the "ZPN" are mounted in outriggers to which power is transmitted through a series of gears and shafts from two 800 h.p. seven-cylinder, Wright "Cyclone" air-cooled engines, housed in the control car of the airship. Usually both engines are in simultaneous use, but either can drive both propellers when required, such as during low-speed operations or to conserve fuel on long patrols. The "ZPN" is the fifth and largest of a series of non-rigid airships which have been built by the Goodyear Aircraft Corporation for the U.S. Navy. More than 130 blimps of a previous design, termed the "ZPK," were used extensively for anti-submarine operations during the last war. The gas envelope of the "ZPN" has a capacity of 875,000 cubic feet of helium, 150,000 cubic feet more than its immediate predecessor, which, at present, holds the world's sustained flight record of more than a week without refuelling. It approaches in size the rigid dirigibles built during the first world war.

American Contracts for U.K. Shipyards

At present United States shipbuilders find it almost impossible to compete, except on a delivery basis, with foreign shipyards for the construction of tonnage required by American industrial carriers. This is especially the case when the industrial carrier operates between a foreign port and United States ports, carrying its own raw materials for manufacturing purposes and is not subject to the restrictive American coastwise laws. Under these conditions the trend is now for the industrial carrier to register a new vessel in a foreign country for foreign flag operation. For example, this will be the case with the two 22,400-ton ore carriers being constructed for the Liberian Navigation Corporation, a subsidiary of the States Marine Corporation, by the Fairfield Shipbuilding and Engineering Company. These 600ft vessels will fly the flag of Liberia, and have been designed to move ore from Africa to Baltimore for the Republic Steel Company. The vessels will be owned and operated by the States Marine Corporation, which has a contract as a freight carrier to move the Republic Steel Company's ore. The two vessels are being built at a total cost of 5,880,000 dollars and each will be propelled by a single Doxford diesel engine of 8500 b.h.p., producing a sea speed of 14¾ knots. Largely due to the higher American shipbuilding costs, a considerable number of orders for oil tankers and cargo vessels have been placed recently with British, Dutch, German, Swedish and Japanese shipyards. The indications at present are, however, that, except for Japanese and Italian shipyards, shipbuilders in practically all foreign nations will be unable to offer early delivery dates and their costs, too, have been rising steadily. Details of some vessels which have recently been ordered from United Kingdom yards by American interests are given in the following compilation.

The Aluminum Company of America, through its affiliate, the Pan-Ore Steamship Company, which is associated with the Alcoa Steamship Company, has placed an order for an additional bauxite bulk ore carrier. It will be built by the Burntisland Shipbuilding Company and be similar in general characteristics to the two completed last year for Alcoa by Hawthorn, Leslie and Co. However, instead of diesel propulsion, as in the first two, the new vessel will be propelled by double-reduction geared turbines, with steam supplied by high-pressure water-tube boilers. The vessel will operate at 12½ knots loaded to a maximum draught of 20ft 6in. An identical vessel will be constructed by the Burntisland Shipbuilding Company for Skibsaktieselskapet Karaibien. This vessel also will be utilised by the Aluminum Company of America for the importation of bauxite along with its own vessels. A bulk carrier ordered by the Reynolds Jamaica Mines, Ltd., a subsidiary of the Reynolds Metals Company, will be of a self-unloading design. It will be built at the Barrow yard of Vickers-Armstrongs and will be of about 15,500 tons. Propulsion machinery will consist of single-reduction geared-turbines and two Foster-Wheeler water-tube boilers, producing a sea speed of 15 knots. The self-unloading equipment will discharge ore at a rate of 1400 tons per hour, completing total unloading in about eight hours. The vessel will operate between the Island of Jamaica and the Gulf Coast of the United States. Six 12,500-deadweight-ton cargo ships are to be built by the Fairfield Shipbuilding and Engineering Company for Global Transport, Inc., an affiliate of the States Marine Corporation. These vessels will be 440ft long between perpendiculars, 61ft 6in beam and 40ft 9in depth. Propulsion machinery will be single-screw, double-reduction geared-turbines of 7000 s.h.p., steam being supplied by two water-tube boilers. The two super-size oil tankers recently ordered by the Standard Oil Company of New Jersey, from Vickers-Armstrongs, will be essentially duplicates of the ten vessels built by the Newport News Shipbuilding and Dry Dock Company for the Standard Oil Company. They will be 601ft 2½in long between perpendiculars, 82ft 6in beam, 42ft 6in depth and will be propelled by double reduction geared turbines developing a maximum of 13,750 s.h.p. The deadweight carrying capacity will be almost 27,000 tons. The four tankers ordered in March in Great Britain for the Esso Petroleum Company will also be duplicates of the Newport News design. Two will be built by Vickers-Armstrongs, one by John Brown and Co., and one by Cammell Laird and Co. The two tankers ordered by the Gulf Oil Corporation, one each from the Furness Shipbuilding Company and John Brown and Co., will be of 32,000 deadweight tons. They will be 630ft long between perpendiculars, 85ft 6in beam, 45ft depth and will be propelled by double-reduction geared-turbines of 13,750 s.h.p. maximum. Plans of the Gulf Oil Corporation to build tankers of 42,000 tons have been abandoned due to the unfavourable delivery dates offered for vessels of this size, which is partly due to the great amount of new design development work which would first have to be accomplished. The new order recently placed by the Tidewater Commercial Company of Baltimore, with John Brown and Co., is for a duplicate of their tanker now being built at the Brown yard. However, instead of diesel propulsion as in the case of the first vessel, the owners have changed to geared-turbines for the second vessel. These vessels will be 535ft 6in long, 72ft beam, 41ft depth and of 19,000 deadweight tons. Both will be documented in Panama. The two oil tankers ordered by the Atlantic Oil Carriers, New York, from the Fairfield Shipbuilding and Engineering Company will be of 19,500 tons each. The vessels will be 545ft long between perpendiculars, 71ft beam, 40ft 6in depth and will be propelled by double-reduction geared-turbines of 8000 s.h.p. Orders for a total of ten tankers have been placed with British shipyards by the Overseas Tankship Corporation, a company which is controlled by the American Caltex group, a combination of the Standard Oil Company of California and the Texas Company. Two 18,000 ton and one 16,500 ton vessels are being built by the Furness Shipbuilding Company; three 16,500-ton vessels by Hawthorn, Leslie and Co., and four 12,200-ton vessels by Wm. Doxford and Sons. It is of interest to note that the volume of shipbuilding business placed in foreign shipyards by American shipping interests totals 1,630,310 deadweight tons, as compared with 1,346,740 deadweight tons now under construction in the United States. The contract value in foreign currency of the ships ordered from foreign shipyards by American shipowners amounts to approximately 240,000,000 dollars. If these ships were built in the United States instead of in foreign countries, they would cost approximately 326,000,000 dollars, or 31 per cent more.

French Engineering News

(From our French Correspondent)

A 60MVA synchronous condenser is to be installed at Le Havre for Electricité de France, at the Harcourt substation near Issy-les-Moulineaux. The machine will be employed on highly loaded networks where it is difficult to maintain normal voltage by other means.

* * *

A new vessel of the Compagnie Générale Transatlantique, the "Ville de Marseille," recently left Marseilles for North Africa, where it will be placed in regular service on the Bordeaux-Casablanca line. The ship is 142m long, and 19·45m wide, and will carry 797 passengers in four classes. It can take 4755 cubic metres of merchandise of which 2500 cubic metres can be stored in refrigerated holds. Its deadweight is 9400 tons.

The Compagnie Générale d'Armements Maritimes has brought a new cargo vessel, the "Saint Ferreol," into service. It has a deadweight of 4255 tons. A cargo vessel for the Moroccan line, the "Saffi," has been launched.

* * *

The first part of the re-equipment programme at the Sté des Forges de Gueugnon will be completed this year. It comprises the installation of a cold rolling mill for special work and stainless steel plate, mechanisation of the hot rolling equipment, the installation of new, mechanised rolls and the provision of equipment for tempering, cutting and finishing. The production of stainless steel plate has already been increased by 50 per cent. The second part of the programme will cover further installation of rolling plant for stainless steel strip.

* * *

Electrification by the S.N.C.F. in 1950 was the subject of a recent technical study. The work carried out included the completion of the Paris-Laroche section of the main line from Paris to Lyon, thus completing the electrification between Paris and Dijon. In addition, electrification in 20kV, 50c/s, single-phase alternating current of the Aix-les-Bains-Annecy route was started, on which the first electric trains ran in June, 1950. Completion of the Annecy-La Roche-sur-Foron section is envisaged this year. During the year the S.N.C.F. also completed the Saint Pierre-des-Corps and Aubrais stations, and installations were modified on the Paris-Tolbiac and Saint-Jory lines. In 1950 the Bious hydro-electric scheme came into service, with an annual production of 25 million kWh and 10MVA installed capacity. A dam is to be built to give a reservoir of 6·7 million cubic metres. In the same year the Oule barrage was enlarged to increase the reservoir capacity from 6·7 to 16·7 million cubic metres, thus allowing 15 million kWh of power, previously available only in the spring, to be stored for use in the winter.

* * *

The reconstruction of the Lessart viaduct over the Rance, which was destroyed by the Germans in 1944, has involved the construction of a large arch of plain concrete with a span of 83·80m and a rise of 23·30m. The viaduct is carried on a spandrel superstructure over a length of almost 38m in the middle of the arch, and on three semicircular arches, each of 7·65m span, on either side. The arch was cast on timber centering supported at each abutment on substantial temporary abutment frames of reinforced concrete. The centering had a span of 77·80m and a rise of 22·38m and was 2·68m in depth and 6m wide. It consisted of eleven similar arch trusses, 0·60m apart, cross braced on the inner surface by a grillage of beams, and on the outer surface by the planking forming the arch shutters. This planking consisted of a double bed of 27mm planks, placed perpendicular to each other at 45 deg. to the axis of the centering. The main concrete arch varies in thickness from 3·80m to 2m and was cast in three stages. The centering was strong enough to carry only the weight of the first stage. The second stage was cast on the first, which supported it, and the third on the first two. The Lessart viaduct is the largest non-reinforced concrete arch in France.

Industrial and Labour Notes

The Employment Situation

According to the statistics issued monthly by the Ministry of Labour, the working population increased by 20,000 (all women) during May. At the end of that month it totalled 23,287,000 (15,937,000 men and 7,350,000 women). Of that number, 822,000 were serving in the Forces, and 22,256,000 (14,997,000 men and 7,259,000 women) were in civil employment, compared with 22,210,000 a month previously.

At the end of May, 4,153,000 people were at work in the country's basic industries, the major increase in these industries being in agriculture and fishing, which added 21,000 to their labour forces during the month. In coal mining, manpower declined during May by 1000, the number of wage earners on colliery books being 702,000, compared with 689,000 at the end of last year. For the first time for several months, there was a net decline in May of 5000 in the number of people working in the manufacturing industries. The total labour force of those industries at the end of the month was 8,687,000. The decline was most marked in the "metals, engineering and vehicles" group, where the number employed fell from 4,119,000 to 4,114,000, a decrease which no doubt reflects the prevailing scarcity of raw materials. As to other industries, the Ministry's figures show an addition of 5000 to the number employed in building and contracting, and an increase of no less than 22,000 in the number engaged in "professional, financial and miscellaneous services."

Unemployment figures included in the Ministry's statement relate to the position on June 18th, when 190,776 people were registered as out of work compared with 215,682 on May 21st. The Ministry says that the June figure was about 0·9 per cent of the estimated total number of employees. It included 7459 people described as "temporarily stopped," and 33,974 married women, many of whom were probably leaving industry.

Railway Staff Training Courses

The Railway Executive has arranged four courses, each of two weeks' duration, as part of the development of the training and education of railway staffs. The courses, which will be held at Ilminster, Somerset, are designed to give an understanding of some of the problems facing the railways, and to arouse the interest and secure the co-operation of the staff in dealing with them.

The subjects to be discussed include the organisation and integration of British transport; background problems of the railways, such as their relations with the customer and railway staff matters, and general items relating to report writing, plans and diagrams, and costs and charges. It is expected that about thirty railwaymen, drawn from all regions and grades of the staff, will attend each course.

A Works Conference

A party of 400 employees of John Thompson, Ltd., Wolverhampton, recently attended a week-end conference at Pwllheli, which was arranged by the firm. The party included directors, works managers, supervisors, welfare committees and apprentices. There were three conference sessions for supervisors, welfare committees and apprentices.

This conference, we are informed, was a sequel to a series of week-end conferences arranged by the firm and held last year at Church Stretton. As a result of those conferences, there came into being the John Thompson Supervisors' Association, the principal aim of which is to provide a direct contact with top management and to foster better relationships between management, supervisors and workmen generally. During this year's conference emphasis was given to the opportunities available throughout the group for trade, indentured and commercial apprentices. To the welfare committees, the importance of works' safety was stressed, and to the supervisors an appeal was made for special effort in the scrap drive in view of prevailing difficulties concerning steel supplies.

The Factory Inspectorate

In a written reply to a Parliamentary question, the Minister of Labour, Mr. Robens, states that on July 1st the factory inspectorate numbered 331, the number of factories, at the end of last year, for which the inspectorate is responsible being 241,064. The reply explains that allocation of work among inspectors is not based on numbers of factories, but on the nature and amount of the work to be done. The Factories Act does not lay down a standard of "substantial inspection," and it would be difficult to hazard a guess as to the average amount of time required for an inspection.

The Ministry of Materials

Under the Transfer of Functions (Various Materials) Order, 1951, the Ministry of Materials assumed its functions on July 12th. The Ministry's headquarters are at Horse Guards Avenue, Whitehall, S.W.1, where the Minister, principal offices and metals division are now accommodated. That part of the Ministry which consists of staff of the Board of Trade will continue, for the time being, in its Board of Trade offices. The Regional Controllers of the Board of Trade will act for the Ministry of Materials.

Sulphur Allocations

The sulphur committee of the International Materials Conference has unanimously recommended to Governments an allocation of world supplies of sulphur for the third quarter of this year. The eleven Governments represented on the committee have accepted the recommendations. The allocation is of crude sulphur only, and the committee has not sought to allocate the relatively small quantities of sulphur which enter into international trade as crushed, ground, refined and sublimed sulphur, or in the form of flowers.

The United Kingdom's allocation for the third quarter is 106,300 tons, the import quota being 105,000 tons. The committee emphasises that the figures announced represent firm allocations, and also says that its recommendations for the fourth quarter will be made by September 10th. In reaching its present conclusions, the committee has considered a number of factors, including forward requirements, trends of past consumption, the availability of sulphur-bearing materials other than native sulphur, the level of stocks, the conversion programmes now in hand in certain countries, and the special needs of defence.

The Nation's Youth and Manpower Needs

The Ministry of Labour has arranged a series of lectures, in connection with the Festival of Britain, under the general title of "The Worker in Industry." The purpose of the lectures is to bring together the latest thought and records of practice on the more important aspects of manpower. It is intended that the lectures shall focus attention on the efficient and economical use of labour, showing the progress made during the last 100 years, and also describing the main problems of the present time.

The first lecture in the series was given in London on Thursday of last week, by Lord Piercy, Chairman of the National Youth Employment Council, whose subject was "The Nation's Youth and Manpower Needs." Lord Piercy said that the main question was that of efficiency, or greater production per head, a production which would permit more saving and investment as well as a high consumption and "massive" social services. Our present educational system, he suggested, affected the manpower problem in two ways. It withdrew for a longer period of education a substantial number of potential workers from industry, and it released young people for industry at an age which was late when compared with former ideas. The problems of reception into industry and training had thus been transformed.

Lord Piercy went on to say that the scarcity of young recruits had considerably increased the sense of responsibility of employers in taking them into industry, and it had also stopped a lot of blind-alley employment. He thought, however, that to secure the best results, there must be carefully devised arrangements for the reception of young people into industry, and that there should be carefully planned arrangements for their training.

United Kingdom Trade Figures for June

According to the provisional figures just issued, the United Kingdom exports in June amounted to £200·0 million, or 13 per cent below the figures for April and May. April exports included consignments which, owing to shipping difficulties, had been held up in earlier months of this year and the May export total had been inflated by abnormally heavy exports of ships. In spite of the lower figure for June, exports in the second quarter of this year (£660·3 million) were 14 per cent higher than in the first quarter and the total for the first half-year was 14 per cent above the 1950 average.

The value of imports increased by a further 6 per cent between May and June to £359·8 million, bringing the import figure for the first half-year to £1859·2 million, a rate of 43 per cent higher than the 1950 average. Imports in the second quarter (£1011·1 million) were 19 per cent more than in the first quarter and it is stated that until the detailed figures are available no estimate can be made of the extent to which this increase was due to a higher volume of imports and how much to price increases.

With re-exports in June at £8·6 million, the total value of exports and re-exports for the first half-year was £1304·5 million. The excess of imports (valued c.i.f.) over total exports (valued f.o.b.) for the half-year was £554·8 million compared with £347·9 million in the whole year 1950.

European Scrap Metal Supplies

A panel set up by the United Nations Economic Commission for Europe considers that Europe would be able to satisfy to a large extent its present demands for scrap for iron and steel production if countries would increase scrap collection and direct available scrap for its most effective immediate use. It is suggested that interested countries should study jointly the possibility of providing financial and other support for schemes to recover scrap from other than normal sources, such as the deserts of North Africa, abandoned wrecks and sunken ships. Substantial quantities of scrap might be recovered from such sources during the next few years if adequate financial help and equipment could be provided.

The panel advises purchasing countries to secure their imports exclusively either through organisations set up for that purpose or through specialised and organised buyers. This advice arises from the fact that certain buying practices in the last few years have seriously upset the European market by the introduction of speculative elements, resulting in the freezing of stocks. European countries with a scrap surplus, it is considered, should, in disposing of such scrap, give priority consideration to the need for maximum production of steel in Europe. It is also urged that the abnormally high percentage of steel-making scrap consumed in blast-furnaces at present by certain countries should be substantially reduced to the extent that availabilities of iron ore and coke permit.

Notes and Memoranda

Rail and Road

CENTRAL TRANSPORT CONSULTATIVE COMMITTEE APPOINTMENT.—The Minister of Transport has approved the appointment of Mr. M. A. Cameron, who has been nominated by the British Transport Commission, to be a member of the Central Transport Consultative Committee in place of Mr. Miles Beevor, who has resigned.

SOUTH LONDON TRAM CONVERSION SCHEME.—On the night of July 10th/11th, the fourth stage of the scheme for converting South London's tram routes to oil-bus operation came into effect. This stage, the smallest of the nine, involved the replacement of two tram routes and one bus route by three new bus routes, whilst two existing bus routes were extended. In it thirty-three trams were withdrawn and thirty-eight buses introduced into service.

SOUTH AFRICAN BUILT DIESEL LOCOMOTIVE.—We are informed by the Hunslet Engine Company, Ltd., of Leeds, that the first diesel locomotive for handling main line wagons to be built in South Africa has been completed at Johannesburg by Hunslet Africa (Pty.), Ltd., and is at work in a large timber yard at Germiston. The locomotive is handling incoming and outgoing timber trollies and wagons for the South African Railways and performing all the internal shunting of the yard. This 3ft 6in gauge locomotive has a Gardner 6LW engine, giving 100 h.p. at 1700 r.p.m. on site, which is nearly 2000ft above sea level. The drive is taken through a two-step transmission, giving track speeds of 4 m.p.h. and 8 m.p.h., the corresponding tractive efforts being 7000 lb and 3500 lb. The locomotive weighs 13¼ tons and hauls loads up to a maximum of 400 tons on the level.

LIVERPOOL CARRIAGE CLEANING DEPOT.—The cleaning, heating and lighting of 150 railway carriages a day will be more efficiently carried out under a scheme evolved by the London Midland Region of British Railways for the modernisation and renovation of the carriage cleaning depot at Downhill sidings, Liverpool. The work will cost some £58,000 and includes the installation of equipment for the vacuum cleaning of carriage upholstery, the preheating of trains, brake testing and the charging of the train batteries which light the compartments. Facilities for the supply of water to the trains will also be improved. Respacing on the sidings and the erection of concrete platforms and modern lighting will facilitate the cleaning and maintenance work, and modern amenities for the eighty men and women employed to clean the trains will be provided. The work is expected to be started in the early autumn.

MR. H. G. IVATT.—It is announced that Mr. H. G. Ivatt, who last month retired as Chief Mechanical Engineer, London Midland Region, has accepted a seat on the board of Brush Bagnall Traction, Ltd., to which company he will be available as technical consultant on diesel-electric locomotives. Mr. Ivatt is the last person on the British Railways to hold the title "Chief Mechanical Engineer." He first held that position on the L.M.S. and has been with the London Midland Region since nationalisation in 1946. During his career with the railways Mr. Ivatt was responsible for the design of the Class "2" and Class "4" 2–6–0 locomotives, which are being used as a basis for three of the standard locomotives, and of the main line diesel electric locomotives, No. 1000 and No. 1001. The latest project in the locomotive field for which Mr. Ivatt has been responsible, and which has just gone into operation, is the "Fell" locomotive, which was described in our issue of June 1, 1951.

Air and Water

MINISTRY OF TRANSPORT FLAG.—In future troopships and emigrant ships owned or chartered by the Ministry of Transport will fly a blue ensign incorporating the Ministry's badge, which has been approved by the King, and which is described heraldically as "An anchor argent in front of and interlaced with wheel gules, &c. ensigned with the Royal Crown."

WORLD TANKER FLEETS.—A biannual analysis of world tanker tonnage issued by Davies and Newman, Ltd., for vessels of over 500 tons gross completed and launched on July 1st, shows that since January 1st the world total has increased by 1,400,000 tons deadweight, the U.S. reserve fleet being excluded. The American fleet forms 24·9 per cent of the total, while Great Britain has 22·7 per cent and Norway 15·7 per cent. The grand total is 28,177,856 tons deadweight and compares with 16,078,000 tons deadweight in 1939.

REPAIR OF THAMES WEIRS.—At a recent meeting of the Thames Conservancy Board, it was reported that work on the repair of several weirs was being put in hand. The work includes the reconstruction of Caversham main weir and lasher weir; the reconstruction of three rymer weirs at Culham, and repairs at Streatley weir. Government sanction is to be sought for the reconstruction of Old Windsor lock and of Sonning rymer weir.

SHIP FOR ROYAL TOUR.—The Shaw, Savill and Albion liner "Gothic," which was built by Swan, Hunter and Wigham Richardson, Ltd., has been selected to carry the Royal party to Australia and New Zealand at the beginning of 1952. Of 14,700 gross tons and having accommodation for eighty first-class passengers, the ship has a service speed of seventeen knots and will be refitted for the tour by Cammell Laird and Co., Ltd.

SCHOLARSHIPS FOR MERCHANT NAVY OFFICERS.—Four new scholarships and bursaries are to be endowed by the Shell Petroleum Company, Ltd., from September, 1951, to assist boys in obtaining training, whose parents cannot afford the cost of such training. "The Shell Scholarship," to a value of £233 10s., £227 10s., and £253 per annum, respectively, will be available at each of three nautical training establishments, namely, H.M.S. "Conway," H.M.S. "Worcester," and Gordonstoun School, Elgin, Morayshire. Awarded annually, it will be tenable for two years. In addition an annual grant of £300 for the provision of bursaries is to be made to the Nautical College, Pangbourne, Berkshire.

NEW RADIO BUOY.—A radio buoy, with an automatic transmitter, sponsored by the electronics division of the Venner organisation, is intended primarily for use with the fishing fleet and will assist fishermen not only to locate their catch quicker, even in foggy weather, but reduce the risk of losing nets. The call sign is the same as the parent ship plus a numeral, and the mast light can give either a flashing light three seconds on and six seconds off continuously or a flashing light of the same character at the same time as the transmitter is in operation. The transmitting cycle can be constant with a ratio of one unit for every six units of silence or the transmitter can be set so that transmission will commence at any period within the following seven days. Operation is simple and the accumulator may be charged, without being removed, through an outside socket. The buoy has many applications and the transmitter can be supplied in a water-tight case with harpoon attachment for use with the whaling fleet, or it can be used as an automatic transmitting unit for lifeboats.

Miscellanea

INTERNATIONAL MACHINE TOOL EXHIBITION, LONDON, 1952.—At a recent meeting of the Machine Tool Trades Association, Mr. Robert W. Asquith, the president, gave an assurance that unless an official state of emergency arose, the International Machine Tool Exhibition will be held as planned, at Olympia, London, from September 17 to October 4, 1952. Mr. Asquith, who is also chairman of the Exhibition Committee, stressed the advantages accruing from such an exhibition, and said that the council of the Association had solid grounds for believing that the exhibition will prove of real benefit to the industry and will be well supported.

BRITISH INSTITUTE OF MANAGEMENT.—On July 2nd the British Institute of Management elected Dr. Lillian M. Gilbreth as its first Honorary Fellow. In making this announcement the Institute points out that Dr. Gilbreth and her husband, who died in 1924, were the originators of motion study and two of the pioneers of scientific management. Dr. Gilbreth is the President of Gilbreth Incorporated, and a member of the board of directors of the American Management Council of the U.S.A. From 1935 to 1948 she was Professor of Management at Purdue University. She is an Honorary Member of the American Management Association and of the Society for Advancement of Management.

THE TREATMENT OF FACTORY VISITORS.—An interesting and instructive booklet, which has been prepared by Tube Investments, Ltd., and issued to all concerned in its subsidiary companies, is entitled "A Guide to the Proper Treatment of Factory Visitors." Although the subject is treated in a light vein many very useful hints are given and the importance of the correct approach and treatment of visitors of all kinds is stressed. This book, which should be read by all executives and members of works staffs who deal with visitors, is, we understand, being published for general sale by the British Association for Commercial and Industrial Education, Management House, Hill Street, London, W.1

USE OF BRITISH ATOM PRODUCTS.—Products of British atomic energy research are being used for beneficial purposes by countries all over the world and reports from a number of these countries will be given at the International Conference on Isotope Techniques, which opened in Oxford on July 16th, and will close on July 21st. This is the largest international conference of its kind yet to be held in Britain and is a result of the rapid increase in practical uses of radioactive materials. The opening address of the Conference was given by Sir John Cockcroft, Director of the Atomic Energy Research Establishment, Harwell.

TIMBER SUPPLY PROSPECTS IN 1951.—While the probable import demand in Europe for sawn softwood is likely to continue in 1951, the supply outlook gives no cause for alarm, according to a report published in Geneva by the Secretariats of the United Nations Economic Commission for Europe and the Food and Agriculture Organisation. The supply situation of pit props and pulpwood, however, appears more serious. In addition to country-by-country timber market analyses, the report contains statistics for 1950, compared with previous years. It shows that eighteen European countries produced 6,378,400 standards of sawn softwood last year, compared with 6,442,800 in 1949 and 5,551,400 in 1948. Eleven European countries exported 2,726,500 standards of sawn softwood during 1950, against 2,209,800 in 1949. Sixteen European countries imported 2,439,700 standards of sawn softwood in 1950, compared with 2,401,300 in 1949. Stocks of sawn softwood in fourteen European countries dropped to 1,233,800 standards on January 1, 1951, from 1,611,300 on the same date in 1950.

Personal and Business

MR. DAVID EWAN has retired from the position of senior chief engineer of the Shell tanker fleet, after completing thirty-five years' service with the company.

CAPTAIN J. P. THOMSON is retiring at the end of July, after completing seventeen years as marine superintendent of the Eagle Oil and Shipping Company, Ltd.; he will be succeeded by Captain D. W. Mason, G.C.

MR. F. J. STEPHENS has been appointed a Managing Director of the Anglo-Saxon Petroleum Company, Ltd., and of the Shell Petroleum Company, Ltd., and a delegate member of the Board of N.V. de Bataafsche Petroleum Maatschappij, The Hague.

BRAMPTON FITTINGS, Ltd. (with which is associated Walton and Brown, Ltd.), the Birmingham cycle component manufacturers, announces the appointment of Mr. E. Archer as a director and joint general manager with Mr. T. Watson, who is works director.

THE DEPARTMENT OF SCIENTIFIC AND INDUSTRIAL RESEARCH, HYDRAULICS RESEARCH ORGANISATION, announces that in future all correspondence for Sir Claude Inglis and the Hydraulics Research Organisation should be addressed to The Director, Hydraulics Research Station, Howbery Park, Wallingford, Berks. The telephone number is Wallingford 2381.

MR. H. K. MILLER, who became personal assistant to Mr. William Sinclair, director of the Dunlop Rubber Company (Scotland), Ltd., upon the formation of the Scottish company in 1946, has been appointed its sales secretary. Mr. Miller, who has been at the Glasgow depot since he joined the company twenty-three years ago, is secretary of the Scottish Tyre Register Committee of the Tyre Trade Joint Committee and of the Scottish Register Committee of the Golf Ball Manufacturers' Conference.

Contracts

LEYLAND MOTORS, Ltd., announces that the biggest single export order so far secured by the company has just been placed by the Argentine for 750 of the latest underfloor-engined buses. This order, which is worth nearly £4,000,000 sterling, exceeds both in size and value, the ten million dollar contract which Leyland received from Cuba last July for 620 buses to replace the tramcars in Havana. All the buses covered by the order will be the latest 125 h.p. diesel types, in which the six-cylinder engine is mounted between the front and rear axles under the floor of the passengers' saloon. Of the vehicles, 450 will have "Royal Tiger" underfloor-engined chassis, and 300 will be "Olympic" chassisless vehicles, which incorporate Leyland running units with bodies built by Metropolitan-Cammell-Weymann Motor Bodies, Ltd.

British Patent Specifications

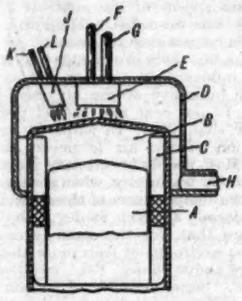
When an invention is communicated from abroad the name and address of the communicator are printed in italics. When an abridgment is not illustrated the specification is without drawings. The date first given is the date of application: the second date, at the end of the abridgment, is the date of publication of the complete specification.

Copies of specifications may be obtained at the Patent Office Sales Branch, 25, Southampton Buildings, Chancery Lane, W.C.2, 2s. each.

AIR ENGINES

654,638. February 3, 1947.—Hot Gas Reciprocating Engines, Thomas Dudley Threadgold, of Century House, Shaftesbury Avenue, London, W.C.2. (*communicated by N. V. Philips' Gloeilampenfabrieken, of Emmasingel, 29, Eindhoven, Holland*).

In the drawing the engine comprises a piston *A* and a cylinder *B*. The top of the cylinder wall is provided with ribs *C*, both inside and outside, and is surrounded by an envelope *D*, in which a heater device *E* is provided having two connections *F* and *G* through which fuel and combustion air respectively are supplied by pumps driven by the engine itself. The combustion products escape through a discharge tube *H*. To start up the engine after a period of inoperation it is necessary for the head

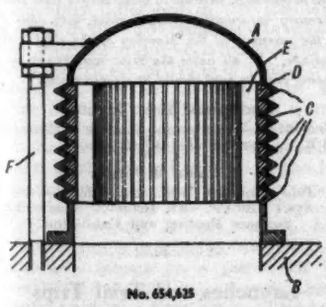


No. 654,638

of the engine to be heated to a suitably high temperature. A second heater *J* is therefore provided, with two connections *K* and *L* through which fuel and combustion air respectively may be supplied. In this case, however, supply cannot be effected by engine-driven pumps, and the fuel may flow to the heater from a container at a higher level, or, if use is made of gaseous fuel, from a pressure container. Combustion air may also be supplied under pressure. To prevent overheating of the cylinder head, the fuel container to which the conduit *K* is connected may have a capacity such that when the required temperature is approximately reached, the available fuel is exactly consumed. Secondly, cocks provided in the conduits *K* and *L* may be governed by a clockwork mechanism. Finally, it is possible to provide means acting at a definite temperature, such as a thermometer or a bimetallic strip, inside or near the head of the cylinder, to shut off the conduits when the operating temperature is reached, so that the heating device is made inoperative at the definite temperature.—*June 27, 1951.*

654,625. April 30, 1946.—Hot Gas Engines, N. V. Philips' Gloeilampenfabrieken, of Emmasingel, 29, Eindhoven, Holland.

An object of the invention is to provide a means whereby the minimum thickness of the heater shell can be made smaller than is possible in the known



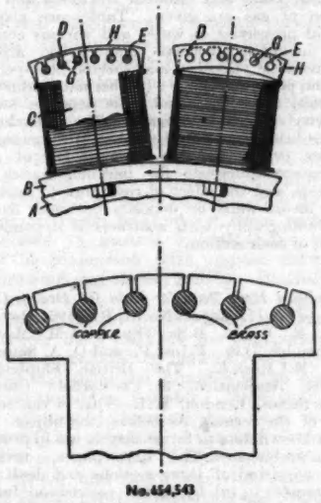
No. 654,625

constructions. The advantage is thus obtained that the resistance to the flow of heat through the shell is decreased. The drawing shows a sectional view of the head of a hot gas engine. A dome-shaped outer shell *A*, which is made from material of high-tensile strength at high temperature, such as nickel-chromium steel, is secured to the cylinder *B* of the engine by means of a flange. The shell is partly corrugated in the circumferential direction and as shown in the drawing the wall thickness at the corrugations *C* is smaller than that at the non-corrugated portion. The presence of these corrugations ensures that the absorption of heat by the head from the flue gases of the burner flowing along the outside of the shell takes place more thoroughly than if the outside of the shell were smooth. Against the inside of the shell there is a cylinder *D* consisting of a material having a low resistance to the flow of heat, such as aluminium bronze. In the cylinder there are formed axial bores *E* through which the working medium flows and absorbs heat. To give the head the required strength in the axial direction, it is supported by means of rods *F*, only one of which is visible in the drawing, screwed into the top of the engine cylinder. —*June 27, 1951.*

ELECTRICAL ENGINEERING

654,543. August 6, 1948.—Dynamo-Electric Machines, The British Thomson-Houston Company, Ltd., of Crown House, Aldwych, London, W.C.2.

This invention relates to dynamo-electric machines and, more particularly, to an improved damper winding construction for synchronous a.c. machines. The rotor has a supporting web *A* adapted to be mounted on a shaft, and is provided with a circumferentially extending flange *B* of magnetic material. Salient pole pieces secured to the flange each include a laminated core *C* of magnetic material having winding slots such as *D* (to the left of centre) and *E* (to the right of centre). There is also a damper winding including transverse



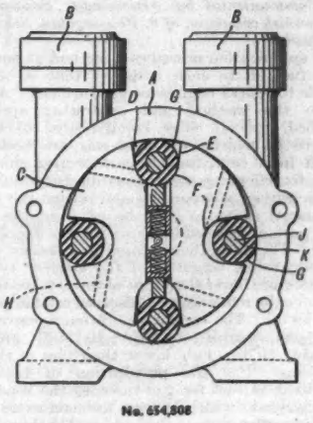
No. 654,543

conductors *G* located in the winding slots *D* and *E*, the transverse conductors being short circuited by end conductors *H* at each side of the pole to complete the winding. The ends of the slot conductors are formed as rivets or being welded to each of the end conductors. In the invention a damper winding which is unsymmetric with respect to the pole piece axis is provided. In the embodiment illustrated in the upper view, this is done by having slots *D* at one side of the direct axis having wider mouths than the slots *E* at the other side. With a counter clockwise direction of rotation, the wide-mouthed slots are in the leading half of each pole piece and the narrower mouthed slots are in the trailing half of each pole piece. This arrangement provides a reactance-resistance ratio with less impedance in the leading half than in the trailing half to provide substantially the same loading in all conductors. In the lower view is shown an alternative method in which the slot structure is identical throughout the pole, but the same result is achieved by using different materials, copper and brass, having different resistivity, for the conductors.—*June 20, 1951.*

PUMPS

654,808. November 23, 1948.—Rotary Circulating Pumps, Alfred George Langdon, of 77, Derby Road, Southampton, Hampshire.

The object of the invention is to eliminate noise, and the roller impeller members each comprise a metal core provided with a coating of rubber or similar material. Referring to the drawing, the pump casing *A* is formed with two ports *B*. The rotor *C* is supported eccentrically within the pump casing by a driving spindle extending outside the pump through suitable glands. The periphery of the rotor is formed with four or any other suitable number of recesses *D* having approximately parallel sides *E*, the innermost part *F* of each recess being curved or rounded to the same radius as the curvature of a roller *G*. Each recess has extending from its innermost end a hole *H* which passes through the rotor to its periphery and in advance of the mouth of the recess, so that as the rotor rotates, liquid passes through the associated hole *H* behind the roller to force it against the casing. This arrangement ensures that the rollers are pressed



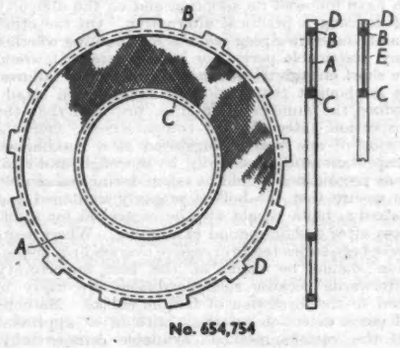
No. 654,808

tightly against, and will run round, the interior of the casing without having to rely on centrifugal force, and also that the pump will run more quietly. In order that the pump shall commence to operate at low speeds at least two of the rollers are arranged to be spring-urged towards the periphery of the rotor by plungers, as shown in the drawing. If desired, all of the rollers may be spring-urged, but this has not been found necessary in practice. The rollers *G* consist essentially of a metal core *J*, having a coating of rubber or like composition *K* which absorbs shocks occasioned by the entry of grit. Another form of the invention without the holes *H* is described in the specification.—*June 27, 1951.*

MISCELLANEOUS

654,754. November 6, 1948.—Disc Brakes, The Dunlop Rubber Company, Ltd., of 1, Albany Street, London, N.W.1, and Henry James Butler, of the works of the Dunlop Rim and Wheel Company, Ltd., Foleshill, Coventry.

The object of this invention is to provide an improved brake disc, which is particularly applicable for use in aircraft disc brakes. As shown in the drawings, the brake disc comprises a thin annulus *A* of beryllium-copper gauze, of approximately 0·02in thickness, secured between an outer annular retaining frame *B* and an inner annular retaining frame *C*. Driving dogs *D* are provided on the outer periphery of the outer



No. 654,754

frame to engage in complementary slots in an associated wheel, whereby the disc is caused to revolve when the wheel revolves. The inner periphery of the outer frame and the outer periphery of the inner frame are each provided centrally with an annular slot and the edges of the gauze annulus are compressed within the slots. As an additional measure to prevent relative rotation between the gauze annulus and one or both the retaining frames, the gauze annulus may be brazed or welded within the slots. In another modification, illustrated in part sectional elevation, the braking member extends from the inner periphery of the inner retaining frame to the outer periphery of the outer. The inner frame and the outer frame complete with driving dogs, are both divided circumferentially into two equal halves. The braking member *E* is cut from a plain metal sheet and its outer periphery is profiled to correspond with that of the outer retaining frame, including the driving

dogs. The braking member is then sandwiched between the halves of the inner and outer frames and the whole is secured together by brazing or welding.—*June* 27, 1951.

654,886. August 28, 1947.—PURIFICATION OF FUEL OIL, The Alfa-Laval Company, Ltd., Great West Road, Brentford, Middlesex. (*Communicated by Aktiebolaget Separator, a Swedish company, of* 8, *Flemingatan, Stockholm, Sweden*).

The specification describes a method of purifying boiler fuel oil to such a degree that it becomes suitable for diesel engines or gas turbines. According to the method and separating apparatus described, the oil, after being heated to a temperature at which any emulsions are broken, is treated in a centrifugal separator provided with means for effecting continuous discharge of water (as the heavier component) and oil (as the lighter component) so as to free the oil from the water and a part of the solid impurities not dissolved in the oil. The oil is then treated in a second centrifugal separator, which is of the clarifier type, at a temperature lower than that of the first separation, to remove the remaining undissolved solid impurities from the oil. The second separation is carried out at a temperature at least 10 deg. Fah., or preferably 20 deg. Fah. lower than that of the first separation. For the purification of boiler oil to be used as fuel for gas turbines the separators are provided with devices for connecting the inlet and outlet pipes to the bowl so that the oil is not exposed to the influence of the air.—*June* 27, 1951.

Technical Reports

Engine Running-Gear Bolts—Periodical Heat-Treatment, Renewal, or Inspection. (Report No. 38, RB. 401.) By B. Taylor, B.Sc. (Eng.), A.M.I. Mech.E., and R. Cook, M.Sc., A.M.I.Mech.E., A.M.I.Mar.E. The British Shipbuilding Research Association, 5, Chesterfield Gardens, Curzon Street, London, W.1.—Three common practices adopted to avoid the occurrence of fatigue failures in running-gear bolts of marine oil engines are examined. These are (1) periodical heat treatment; (2) renewal after a specified period of service, and (3) periodical examination. None of these procedures removes the fundamental causes of bolt failure, which, in order of importance, are faulty assembly, poor design and, more rarely, faulty material, but the conclusion reached is that periodical examination is the most useful. Periodical heat-treatment of plain carbon-steel bolts is not advisable for the following reasons: (1) it is very doubtful whether any improvement in the resistance to fatigue or repeated shock results; (2) incipient flaws are likely to be intensified, and (3) unless properly controlled there is grave risk of doing more harm than good. The latter consideration applies especially to alloy-steel bolts, where there is also risk of distortion. The case for bolt renewal at specified intervals rests on good results reported to have followed its adoption and on the difficulty of devising a practical alternative. On the other hand, there are strong grounds for doubting whether any practicable period for bolt replacement would be short enough to reduce the incidence of failures. It is thought that periodical examination should reduce the number of failures, provided that the inspection intervals are comparatively short (a period of one year is suggested as a maximum). Inspection must necessarily be thorough, and rigorous precautions should be taken during reassembly to ensure that the bolt is properly tightened and locked; bolts should also be rechecked for tightness after a short period of running. Where bolts have been subjected to excessive overloading, inspection should be made at the first opportunity afterwards because such conditions are likely to lead to the formation of fatigue cracks. Methods of crack detection are dealt with in an appendix. Of the various methods available commercially, those employing magnetic particles or fluorescent-fluid penetration appear to be most suitable for the examination of bolts. Magnetic crack detection is a method for use ashore rather than on board ship. Fluid penetration in its simplest form can be used on board ship but is of doubtful value; the more elaborate versions of this process involve the use of fluorescent penetrant and ultra-violet light.

Simplified Heat Transfer Data for Design Calculations—Part I. (Report No. 17, RB. 155. Second revision.) By G. Brown, B.Sc. (Eng.), M. Fishenden, D.Sc., F.Inst.P., and O. A. Saunders, D.Sc., M.I.Mech.E. The British Shipbuilding Research Association, 5, Chesterfield Gardens, Curzon Street, London, W.1.—This is the first of a series of reports dealing with the calculation of heat transmission. The object is to present known data in forms easy to use in practical design problems. The three sections presented in this initial paper deal with heat transfer: (*a*) by forced convection for the flow of fluids through tubes, fluids of low and high viscosity being considered separately; (*b*) by forced convection for the flow of gases over tube banks. In this case flow normal to the axis of a single isolated cylinder is first dealt with; this is then extended to flow across "in-line" and "staggered" tube banks, the effect of varying the angle of impact also being shown. Both heat transfer and pressure drop are considered for various tube arrangements; (*c*) by radiation to or from both solid surfaces and gases. The most important non-luminous radiating gases are water vapour and carbon dioxide; the emissivities and absorptivities of these two gases are now fairly accurately known and are given for a wide range of temperature, partial pressure of radiating gas and thickness of gas layer. Later sections will include further cases of forced convection, natural convection, the condensation of vapours, the boiling of liquids, &c. Each section is divided into three main parts, which comprise (*a*) fundamental relations; (*b*) equations and charts to be used in design, and (*c*) an example of an actual calculation. In all sections the data, so far as possible, are presented in such a manner that coefficients of heat transfer, expressed in B.Th.U. per hour per square foot deg. Fah., can be read directly from the appropriate charts. This cannot always be done conveniently in a single step and factors or corrections given in subsidiary curves or tables may sometimes have to be used; but the data have in general been reduced to as simple forms as feasible. In the case of gas radiation, families of curves showing emissivity (or absorptivity) for temperatures up to 3600 deg. Fah., and different thickness and composition of gas are given. Tables are given of (*a*) fluid properties of water and various common gases, including thermal conductivity, absolute and kinematic viscosity, and specific heat per unit mass and per unit volume; (*b*) thermal conductivity of metals, refractories and scale deposits, and (*c*) emissivity of solid surfaces. The introduction includes brief accounts of the use of dimensionless numbers or groups, the computation of mean temperature difference for parallel, contra and cross flow, and the effect of resistance to heat flow across metal walls or deposits of scale, &c. A short bibliography with abstracts is appended at the end of each section.

Simplified Heat Transfer Data for Design Calculations—Part II. (Report No. 54, RB. 496. Revised.) By J. E. Bacon, B.Sc. (Eng.), A.M.I.Mech.E., M. Fishenden, D.Sc., F.Inst.P., and O. A. Saunders, D.Sc., M.I.Mech.E. The British Shipbuilding Research Association, 5, Chesterfield Gardens, Curzon Street, London, W.1.—This is the second report of the series. As before, the object is to present known data in forms easy to use in practical design problems. The first paper, reviewed above, consisted of three sections and dealt with heat transfer: (*a*) by forced convection for the flow of fluids through tubes; (*b*) by forced convection for the flow of gases over tube banks; (*c*) by radiation to or from both solid surfaces and gases; This paper includes two further sections, dealing with heat transfer: (*d*) by forced convection for the flow of liquids over tube banks; (*e*) by condensing vapours on the inside and outside of horizontal and vertical tubes and on vertical surfaces. The method of presentation used in the first report has been followed here for section (*d*.) The section is divided into three main parts, which comprise (*a*) fundamental relations; (*b*) equations and charts to be used in design, and (*c*) an example of an actual calculation; a short bibliography with abstracts is also appended. The data, so far as possible, are presented in such a manner that coefficients of heat transfer, expressed in B.Th.U. per square foot per hour deg. Fah., can be read directly from the appropriate charts. As this cannot always be done conveniently in a single step, factors or corrections may sometimes be used; in such cases subsidiary curves and tables are given in the simplest forms possible. Some of the tables and charts are common to Part I and to the present report. They are not repeated here. It is felt that the two reports should be read and used as one. Also in common with Part I, the data have their limitations and nominally refer to simple shapes and clean surfaces. In Section E it is explained that in heat transfer from condensing steam through a metal wall to a gas, the resistance on the steam side is relatively small. Considerable variations in the steam side coefficient have, therefore, little effect upon the overall coefficient and an all-round value may conveniently be taken. Although in many design problems the use of this all-round value is sufficient, nevertheless, a discussion of the basic laws of condensation is included as an Appendix for designers who may wish to make a more fundamental study of the process. This Appendix follows the same pattern as the earlier sections of the work, that is, three main sub-sections plus a bibliography with abstracts.

Comparisons of Convective and Radiant Methods of Heating (Report No. 56, RB. 526. Revised.) By T. Bedford, D.Sc., Ph.D., M.I.Min.E., and M. Fishenden, D.Sc., F.Inst.P. The British Shipbuilding Research Association, 5, Chesterfield Gardens, Curzon Street, London, W.1.—This report has been prepared as part of the research programme on Item M.34 (Ventilation of Passenger and Crew Accommodation) and its object is to compare the advantages and disadvantages of various methods of heating living spaces, and is intended to be used as a basis upon which more detailed consideration of the problems of ship compartments can be undertaken. A heating system and its associated ventilation installation, besides maintaining a suitable degree of warmth, should provide conditions which will give a pleasant, fresh environment. Although feelings of general bodily warmth depend on the summated effects on the body surface of the radiation from the surroundings and the temperature, humidity and speed of movement of the air, impressions of freshness or stuffiness are due to the stimulation or lack of stimulation of local areas of skin. In this report an outline is given of the conditions which make for a comfortable environment and the work of many investigators on the subject is discussed. The importance of adequate air movement has often been stressed. Its beneficial effects are greater in summer than in winter; and in artificially heated rooms speeds of the order of 20ft or 30ft per minute are desirable. Humidity has little influence on sensations of warmth at optimum temperatures, but there is evidence that it may have a distinct influence on comfort. It appears that the relative humidity of the air should certainly not exceed 70 per cent and should preferably be much lower than this. In ships at sea artificial humidification of the air is never likely to be desirable. Most people in ordinary indoor clothing feel comfortably warm, say, when sitting reading or talking, if the temperatures of the air and surroundings are uniformly at about 66 deg. Fah., but actual tests indicate that, for the same equivalent temperature, the environment feels more pleasant when the walls are above 66 deg. Fah., and the air below 66 deg. Fah. Some methods of warming produce steep temperature gradients, the air at head level being much warmer than that near the floor. Such gradients are highly undesirable and may promote acute discomfort. Experimental evidence on this aspect of the problem is discussed in the paper and shows that generally speaking the temperature difference from foot to head level is much less for radiant than for convective heating. This is an additional advantage in favour of radiant methods. It is important to know the heat input required for equivalent warmth by various systems of heating, although they may not produce the same degree of comfort; and one section of the paper deals with this question. The comparisons are based upon both calculated and experimental data. The results are dependent upon too many factors to be expressed in simple terms but, in general, methods giving a proportion of direct radiation should usually produce conditions more comfortable on a slightly lower heat input than methods relying mainly upon air heating. The question of operating cost, as distinct from heat input, is, however, not dealt with. The concluding section of the report summarises the requirements for satisfactory heating.

Forthcoming Engagements

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of their insertion, the necessary information should reach this office on, or before, the morning of the Monday of the week preceding the meetings. In all cases the TIME and PLACE at which the meeting is to be held should be clearly stated.

Incorporated Plant Engineers

Sat., July 21st.—BIRMINGHAM BRANCH: Morning Visit to B.E.A., Heams Hall "B" Station.

Institute of Physics

Mon., July 23rd, to Wed., July 25th.—INDUSTRIAL RADIOLOGY GROUP: 47, Belgrave Square, London, S.W.1. Summer Meeting and Exhibition.

Launches and Trial Trips

WAIMATE, cargo ship; built by Henry Robb, Ltd., for the Union Steam Ship Company, of New Zealand, Ltd.; length between perpendiculars 325ft, breadth moulded 50ft, depth moulded 26ft, deadweight 5200 tons; two eight-cylinder British Polar diesel engines driving a single shaft through a B.T.H. single reduction gear, and two double squirrel-cage magnetic couplings, speed ratio 300 : 150, 2660 s.h.p., ballast trial speed 14¼ knots. Trial June.